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ATMOSPHERIC POLLUTION IN BRITAIN

THE Clean Air Bill that the Government produced at the end of July to implement the principal recommendations of the Beaver Report, which called for legislation, has just received a second reading in the House of Commons. It is in no sense a party measure, and while it conforms closely to the sense and purpose of the Beaver Report, the recommendations of which have won general acceptance, in its present form it may well be regarded as a working draft. As such it has not only been widely discussed in the technical Press, but also at the annual conferences of the National Smoke Abatement Society during September 28–30 and of the Sanitary Inspectors' Association on September 30. Moreover, while the Bill itself says nothing about sulphur compounds, that aspect was emphasized in papers presented, for example, at the symposium on the prevention of atmospheric and water pollution in the chemical industry arranged by the London Section of the Society of Chemical Industry last April and in Dr. A. Parker's Des Vœux Memorial Lecture at the National Smoke Abatement Society's Conference on September 30.

In general, the Bill has been welcomed as likely to go a long way towards implementing the views of the Beaver Committee. Criticism has chiefly been that there are too many escape clauses, and a resolution adopted at the Sanitary Inspectors' Association Conference which welcomed and pledged support to the Bill urged that the reservations or exemptions contemplated in respect of offences should not be allowed to obstruct its aims. It was also suggested that the responsibility for the control of smoke from the industrial processes scheduled in Section 109 of the Public Health Act 1936 should remain with the local authorities, and that it should no longer be necessary to serve notices for smoke nuisance.

Commenting on the Bill at this Conference, Sir Hugh Beaver regretted that the Bill omitted to establish a Clean Air Council or to declare specifically that clean air was to be the national policy. Such a declaration would force nationalized industries to take due account of this matter; and the Clean Air Council would be invaluable in securing co-operation in research, which is difficult to achieve without some centralized body. The Beaver Report itself lists a number of topics on which further research or development work is required, including particularly the possibilities of reducing the amount of sulphur in fuel, of preventing release of the sulphur in the fuel into chimney gases, of removing sulphur from the chimney gas before discharge into the air and of providing more information on the dispersion of sulphur compounds in flue gases after discharge from chimneys of different heights and in all atmospheric conditions.

Matters such as these, and the study of the physiological effects of air pollution in general on health in relation to respiratory diseases and particularly the effects of combinations of sulphur dioxide and smoke, clearly call for co-ordinated effort by a number of research bodies and institutions; one outcome of debate on the Bill in Parliament should be the provision of some satisfactory means of ensuring that concerted long-range research in such matters, and in others upon which the ultimate achievement of a clean air policy in Britain depends, is neither neglected nor starved of adequate resources. This is perhaps one aspect to which scientists might give particular attention. If the proposal for a Clean Air Council is rejected, Parliament should be left in no doubt where the responsibility for effective research in this field rests. If it is suggested that it should be left generally to the Lord President of the Council or the Advisory Council for Scientific Policy, the occasion should be used for a closer scrutiny of the proposed organization, to satisfy Parliament and responsible professional opinion that the organization is adequate and appropriately staffed and provided with funds on a scale and in a way sufficient to ensure continuity of effort. The importance of such co-ordination is further indicated by the announcement on October 7 by the Public Health Committee of the Western European Union that a preliminary study of air pollution is to be made in the seven countries of the Union (Belgium, France, Luxembourg, The Netherlands, the Federal German Republic, Italy and the United Kingdom).

The question of staff may be more formidable than appears to have been recognized in the discussions that have so far taken place. In the absence of a body specifically responsible for research on the many aspects of atmospheric pollution and its prevention, it may be difficult not merely to secure a reasonable balance of effort between those varied aspects and between the short-term and the long-term effort, but still more to ensure that such research effort is not deflected, particularly in the existing shortage of scientific and technical man-power, by the exigencies of other fields of research. Moreover, it is premature to expect local authorities to carry out their greater responsibilities which the Bill proposes to place upon them unless they have at their disposal a much larger and well-trained staff.

Sir Hugh Beaver emphasized this aspect at the Sanitary Inspectors' Association's Conference at Scarborough. He does not think that the magnitude of the task is as yet realized. Pointing out that there are 200,000 furnace chimneys to be watched in the 'black areas', as well as 20,000 steam engines, he emphasized that the sanitary inspector's burden would be greatly increased; in view of the shortage of man-power, he suggested the formation of an inspecting staff below the specialist grades, which would be competent to carry out 90 per cent of the routine work. Moreover, on the other side, the prevention of smoke itself requires the use of better trained staff, and in a discussion at the conference of the National Smoke Abatement Society there was agreement that all stokers of hand-fired furnaces

should be trained and certificated. Mr. Gerald Nabarro, who withdrew his private member's bill on air pollution in favour of the Government's measure, stated that last year only 650 out of 75,000 boilermen employed in industry had been trained to a minimum standard; but he agreed with Mr. Alfred Robens that in two or three years it would be reasonable to insist that only a trained stoker should be in charge of a hand-fired furnace.

It is desirable that the escape clauses of the present Bill should be considered in the light of the demands which the Bill makes for trained staff and the problem of recruiting and training appropriate staff by industry and by the local authorities. There is much force in Mr. Nabarro's criticism that there are too many escape routes for the recalcitrant owner of an industrial chimney, and the three or five years limit suggested by Mr. Nabarro for the reduction of black smoke seems much more reasonable than the seven years proposed in the Bill as it stands. On the other hand, while there may be too many loopholes, there are clauses which promise to prove a nuisance to industry to no useful purpose. The requirement under clause 6 in regard to the measurement of grit and dust from furnaces burning ten tons an hour or more of solid fuel could well be unnecessarily burdensome and so unevenly applied by local authorities as to yield no useful result.

The Beaver Committee recommended that financial assistance should be provided by local authorities and by the Exchequer towards the costs incurred by house owners in converting appliances in smokeless zones and smoke-control areas. The provision in the Bill that the Government should pay 40 per cent, and the local authority at least half of the balance, of the cost of converting domestic grates in smoke-control areas is a reasonable distribution, and is also designed to stimulate local authorities to find out exactly what a smoke-control order will entail before they determine its scope and character. Sir Hugh Beaver, however, suggested at Scarborough that financial assistance to industry is also necessary, and that it could be combined with the elimination of some of the dubious escape clauses.

It will be noted that the Bill makes no distinction between smokeless zones, in which the emission of smoke from chimneys would be entirely prohibited, and smoke-control areas in which the use of bituminous coal for domestic purposes would be restricted. The Beaver Committee proposed the use of the latter term for areas in which the domestic consumption of coal containing more than 20 per cent of volatile matter would be prohibited. If there are valid reasons for regarding it as undesirable or impracticable to make this distinction, on psychological grounds it would be preferable to retain the term 'smokeless zone' rather than to introduce the new term.

In the first place, there is the well-attested success which has attended the introduction of such zones in Manchester and elsewhere. This has depended on the understanding and support of the public, and introduction of a new term could lead to confusion or misunderstanding to no fruitful purpose. More than this: if it is important that care should be taken not to move too far ahead of the financial and technical resources as well as of the man-power which a campaign for clear air involves, it is still more important not to move too far in advance of public opinion. The Clean Air Bill is best regarded as one step in a concerted campaign throughout Britain to be carried out on many fronts, the success of which will depend above all not on legislation but on the understanding and co-operation of the public. The debates on the Bill will doubtless make clear the part which local authorities, the nationalized fuel industries, the Department of Scientific and Industrial Research, the Medical Research Council and other research bodies or professional institutes, the British Standards Institution, business firms and the Government itself will play, by voluntary action as well as under the provisions of the Bill. Some of those responsibilities appear to require further delineation.

While there is need for further thought and clarification in this respect, the over-riding need is for a sustained campaign of public education. This is particularly important in regard to domestic smoke; the desirability of flexibility in this field must not be permitted to encourage laxity. While it can be assumed that public opinion is now firmly in favour of preventing atmospheric pollution, it cannot safely be assumed that all individuals are yet prepared to accept all that is involved in preventing pollution, even from their own chimneys. The practice of 'firing' a domestic chimney instead of having it swept is still too common for that assumption to be sound. Moreover, while most are probably now willing to accept that personal responsibility, provided they know it will be effective because the same obligation rests on all, their co-operation is at once endangered if they see others taking advantage of loopholes or defying the law with impunity.

One matter which calls for further examination here is the availability of supplies of smokeless fuel, particularly for the domestic consumer. The Beaver Report has been criticized as unduly optimistic on this point, though it believes that the rate of progress will be set by administration limits and the replacement of appliances for the next five years. It is important, however, that administrative action in the creation of smokeless zones should not move ahead of the availability of supplies of smokeless fuels, as well as of technical staff and appliances. Otherwise public co-operation will be hindered and frustration engendered—if indeed friction and disappointment do not smother the existing good will.

It is impossible to overstress the importance of securing full public co-operation and understanding, and the provisions of the Bill should be carefully scrutinized in Parliament from that point of view. It bears, moreover, on a further point. The Bill does not anticipate that the cost to the Exchequer of the recommended measures will exceed some three million pounds per annum, or that the cost of the additional technical staff to be appointed by the Ministry of Housing and Local Government and the Department of Health for Scotland will be more than some £40,000 per annum. No estimate is given

of the cost to the local authorities, and here particularly the support of public opinion is essential if the necessary expenditure is to be incurred. It cannot yet be taken for granted that all local authorities in Britain are concerned to prevent smoke.

What stands out above all, however, is the trifling expenditure required locally and nationally to secure for Britain so great a benefit to the national health as well as to industrial efficiency. The Beaver Report estimated that atmospheric pollution is costing the country as much as £250 million a year in direct costs and loss of efficiency. This is equivalent to £10 per head of population in the 'black areas' and £5 per head throughout Great Britain, and it excludes a loss estimated at between £25 and £50 million a year through the imperfect combustion of coal which itself causes much of the pollution. Dr. Parker, in his Des Vœux Lecture, also stressed this material and economic aspect; and apart from the implications for human health and happiness, when it is realized that for a town of 50,000 inhabitants air pollution costs about half a million pounds annually, it is impossible to dispute Sir Ernest Smith's contention at the National Smoke Abatement Society's Conference that reasonable expenditure of even £20,000 a year on proper publicity and education to further its prevention by securing public support for the increased expenditure required would be amply repaid. Nor should it be forgotten that a campaign for clean air is not only imperative as a matter of national policy; it is also an essential element in the national fuel policy which is long overdue, and which the prospect of nuclear power makes the more imperative.

GUY'S HOSPITAL

Mr. Guy's Hospital, 1726–1948

By Dr. H. C. Cameron. Pp. xiv + 520 + 36 plates. (London: Longmans, Green and Co., Ltd., 1954.) 30s. net.

OF all the great London teaching hospitals, Guy's is the only one which is known by the name of its founder, and, apart from the two ancient foundations of St. Bartholomew's and St. Thomas's, none has a more interesting history. The story has been told on several occasions. Nearly all the accounts are short, but in 1892 Sir Samuel Wilks and G. T. Bettany published a very sound history of the institution. The many changes which took place in the succeeding half-century, and the complete break with the old order following the passing of the National Health Act in 1946, rendered a new history desirable. Dr. H. C. Cameron, who was an alumnus of Guy's in the early years of the present century, and who was in charge of the Department for the Diseases of Children from 1911 until he retired in 1945, had greater opportunities than most for absorbing the spirit of the place, and in this work he has with detail and charm retold the earlier story and brought it up to date.

Thomas Guy was born in Tamworth in 1644 or 1645, and was apprenticed to a printer in Cheapside. He soon set up for himself and began to specialize in the printing of cheap Bibles. There followed complications with the Clarendon Press, Oxford, which was then run rather inefficiently; but Guy soon came to an arrangement with the Delegates, and in 1684 he and his partner Parker were formally appointed Printers to the University of Oxford. The appointment lasted only four years, but by then Guy was a highly successful man. He became a sheriff of London in 1694, and he represented Tamworth in Parliament from 1695 until 1707. During this period he had made many gifts to his native place, including a fine group of almshouses and a new town hall. When the electorate rejected him at the election in 1707, he was so annoyed that he threatened to pull down the town hall.

Guy made a very large fortune, and he increased it enormously by his dealing in South Sea stock. In three months in 1720 he made £180,000, which was slightly more than half his gross estate at his death. He had long been interested in St. Thomas's Hospital, had been made a governor in 1704, and was meticulous in the administration of his gifts to convalescents. By 1721 he had decided to found a new hospital and was then discussing the plans. Guy died in December 1724, and he did not live to see his hospital in action, for the first patients were received on January 6, 1726.

In his will, Guy left detailed instructions regarding his hospital. It was to be governed by a general court consisting of not more than sixty and not less than forty governors. The president and treasurer were to hold office for life—unless they resigned or were removed by a special court. Guy envisaged his hospital as a sort of annexe to St. Thomas's, which then stood adjacent to the present Guy's site; and, though he expressed great interest in 'incurables', it is obvious from his will that the governors could admit the same type of patient as was admitted to St. Thomas's, though he hoped that they would be able to remain longer in his hospital. Between 1728 and 1734 the average length of stay of a patient in the hospital was eighty days. By that time there were four hundred beds.

One of the two physicians first appointed to the hospital was the celebrated James Jurin, who was even more distinguished as a natural philosopher than he was as a physician. Of the early surgeons, the best known is Samuel Sharp. The early nineteenth century saw the rise to international fame of the surgeons Sir Astley Cooper and Aston Key. In 1820, Richard Bright was appointed physician, and he was soon followed by Thomas Addison and the pathologist Thomas Hodgkin. With these men Guy's reached the peak of its greatness; but the succession has been ably upheld by many other distinguished men since their time. On its foundation, the salary for a physician or surgeon was £40 a year. The apothecary got £80; but in 1738 this salary was reduced to £50. Richard Stocker became apothecary in 1793, and he and his son James held the post for eighty years. James was a veritable store-room of medical lore, of the type of observation which is not easily imparted to others. When asked to see a young girl who had been sent in as suffering from pyæmia, he shook his head and said that a patient with pyæmia never did up her hair in that manner. Stocker was virtually dean of the Medical School until Frederick Taylor was officially appointed the first dean. In its early years the hospital had wooden beds which were infested with bugs, and the official bug-catcher had the same salary as a physician or surgeon. Perhaps the most lasting and constructive contribu-

tion to the development of the hospital made by one man was that of Benjamin Harrison, jun., who from 1797 until 1848 carried out the exacting administrative role of treasurer with the greatest enthusiasm, firmness and ability.

The complicated early history of the Medical School is fully dealt with in this book. 'Pupils' seem to have been admitted to the wards about 1760, and the students of Guy's and Thomas's could attend operations in both hospitals. As a result of disagreements, new arrangements were entered into in 1769 whereby the lucrative teaching of surgery and anatomy was concentrated at St. Thomas's, while the teaching of medicine, materia medica and chemistry, which as yet did not exist, was to be carried on at Guy's. Thus arose the Medical School of the United Hospitals of the Borough. It was the custom for a teacher to nominate his successor on his retirement. Astley Cooper, a Guy's man, was appointed demonstrator of anatomy in the United Hospitals School at the age of twenty-one. The classes were, of course, held at St. Thomas's, and two years later Henry Cline, a St. Thomas's surgeon, appointed Cooper as joint-lecturer with himself. The brilliance of Astley Cooper as a surgeon, and his great popularity as a lecturer in anatomy and surgery, made the United Hospitals School renowned far and wide. All the lecturers in the School regarded the lectureships as individual to themselves and they retained the fees. When Astley Cooper was about to retire from the lectureship in anatomy in 1825, his nominee as his successor was turned down by the governors of St. Thomas's without reference to the governors of Guy's, and a St. Thomas's nominee was appointed to the post. This was the beginning of the break-up of the United Hospitals School. To make matters worse, the governors of St. Thomas's refused to hand over to Guy's the magnificent collection of anatomical and pathological specimens, personally built up by Sir Astley Cooper, which was housed in the museum at St. Thomas's. The Guy's governors took action, built a museum, dissection-room and lecture room, and Astley Cooper in his old age began to form his second great collection of specimens. The Guy's School was during 1768–1805 the only London school which had organized courses in the medical, chemical and physical branches of medicine.

This fine work could only have been written by someone with a long and intimate knowledge of the hospital. Half the book is devoted to the period 1885–1948. This period, which is practically all subsequent to that covered by the work of Wilks and Bettany, was one of increasing complexity, due to the expansion of the possibilities of medical and surgical treatment, the growth of laboratories, and of rising costs with their consequences. Dr. Cameron deals in great detail with the administrative changes during this period, with the continuous expansion of the School and the additions to its staff, and with the bequests made to the hospital, especially by Lord Nuffield. The great work carried out by Sir Cosmo Bonsor as treasurer during 1896–1910, and as president from the latter date until 1919, is fully dealt with. There can be few persons surviving who know more than Dr. Cameron about the services rendered to the hospital by Sir Cooper Perry. Perry, a classics don, was appointed assistant physician in 1887, and when Steele, the first superintendent, retired in 1893, Perry volunteered to take over his post. Perry later became principal and vice-chancellor of the University of London, and his successor as superintendent, Sir Herbert Eason, followed the same road. Dr. Cameron's discussion of the work of men like Hale-White, Herbert French, Arthur Hurst and Arbuthnot Lane is very sympathetic and interesting.

This book is very well produced, lavishly illustrated, practically free from typographical errors, and very inexpensive. It is a pity, therefore, that it should be marred by minor errors, such as the attribution of the Bright portrait to "F. R. Fay" instead of F. R. Say, and by the fact that, despite the many footnotes, the actual sources of statements are infrequently given. It should also be said that Dr. Cameron seldom gives a quotation, either from a printed or a manuscript source, without changing the punctuation and the orthography. Examples may be found even in the transcriptions of the documents reproduced in facsimile. On pp. 90–94 a transcript is given of a very important document dealing with teaching in the Medical School. Dr. Cameron says that this document has survived; but he gives no reference. Wilks and Bettany also give this document in full, with minor variations; they also state that it has survived, but give no reference. What the student wants to know is where this document, and others, can be examined. Such matters could be rectified in a new edition, and it is to be hoped that Dr. Cameron will soon have the opportunity to do this, and thus to set the seal on his valuable work.

E. Ashworth Underwood

INTERNATIONAL CONTROL OF NUCLEAR WEAPONS

The Bomb

Challenge and Answer. By Prof. Alexander Haddow, Bertrand Russell, Lord Beveridge and Henry Usborne. Edited by Gilbert McAllister. Pp. 160. (London: B. T. Batsford, Ltd., 1955.) 25*s*. net.

In announcing the publication of this book at the world conference of scientists to consider the effects of nuclear weapons, organized in London early last August by the World Association of Parliamentarians, its editor, Mr. G. McAllister, who is secretary-general of that Association, stated that its preparation had been rushed through in three months, to enable publication to coincide with the London conference. There is little, if any, indication of hurried writing in the five essays constituting the book, though there is some padding that on reflexion might have been omitted. Mr. McAllister himself contributes a brief introduction and an essay detailing previous proposals for world government including, for example, those of Clarence Streit, Lionel Curtis and others; but neither in his reference to the past nor to the present does he justify his title, "Practical Steps for a World Authority". The longest of the other four essays is that by Prof. A. Haddow on "The Problem before Mankind", which is essentially an amply documentated summary of present knowledge as to the effects and probable hazards, especially biological, of nuclear explosions and radioactive exposure in general; it ends with some remarks on the social responsibility of the man of science and the way in which that responsibility might be met.

The remarks lead to nothing more concrete than, for example, the proposal for an international science

council which the late Lord Lindsay made nearly ten years ago in this connexion, and they offer no fresh suggestions for overcoming the practical difficulties. Nor does Lord Russell's essay, "The Road to Peace", take the reader any further than the argument of his earlier books or his broadcast appeal at the end of last year and the statement which he and his co-signatories made public on July 9. Lord Russell is realistic in his comments on the part which the uncommitted nations must play in persuading Eastern governments that it is futile to attempt to secure merely an agreement not to use thermonuclear weapons. His essay is also useful for its discussion of the limitations on the influence which democratic public opinion can exert; but he scarcely faces the practical difficulties which the creation of a world authority would encounter. Much harder and more constructive thought than is manifest in any of these essays will be required if the technical statement of the effects to be expected from a thermonuclear war and its subscription, first by a small number of scientists of outstanding eminence, and then by scientists generally, followed by its interpretation internationally into generally intelligible terms, are to have practical results.

Lord Beveridge's contribution, "The Conditions of Peace", restates the argument for disarmament, the limitation of national sovereignty and establishment of a supranational authority which characterize earlier proposals for world federation without really gripping the practical difficulties. He suggests that the British Government should draft and publish a considered statement of the conditions upon which Britain would be prepared to surrender the right to make war, including that of arming for war, and would make that surrender effective. Such a statement would be an advance on the nebulous renunciation of war of the Kellogg Pact thirty years ago; but its formulation and approval in public debate could only result from the constructive thinking and facing of practical difficulties which for the most part these essays seem to burke.

Mr. Henry Usborne's essay, "The Approach to World Government", includes a similar suggestion; but his contribution is for the most part a rather rambling review of earlier proposals for the international control of nuclear weapons and of the stages by which world federation should be achieved, and he does not deal any more closely with the initial, intangible difficulties than either Lionel Curtis or Clarence Streit. The claim that the book sketches the outline of a world at peace and of those human and political institutions which are the essential foundation and buttress of such a world can scarcely be conceded without reservation. It presents a challenge and reveals how far in human understanding we have yet to go, but is far from providing an answer to the challenge. Its value is rather as a reminder of how much thought has already been given during the past thirty years to the problem of world government, and as a stimulus to the keener thinking that is still required to bring such schemes to fruition. Some of these earlier and more detailed schemes, to which the book directs attention, may well merit re-examination in the changed conditions of to-day. Nor should it be forgotten that the International Conference on the Peaceful Uses of Atomic Energy, which met at Geneva in the weeks immediately following publication of this book, has already resulted in a great relaxation of secrecy in this field and done much to re-establish the normal pattern of communication in the scientific world. The restoration of free communication of thought and ideas, as both Lord Russell and Prof. A. Haddow do not fail to note, is a first condition for the establishment of the climate of opinion and world understanding in which international political institutions can be evolved and rooted. R. BRIGHTMAN

THEORY AND PRACTICE OF NEUTRON DIFFRACTION

Neutron Diffraction

By G. E. Bacon. (Monographs on the Physics and Chemistry of Materials.) Pp. ix+299. (Oxford: Clarendon Press; London: Oxford University Press, 1955.) 35*s*. net.

ALTHOUGH neutron diffraction was demonstrated in the United States in 1936, it is only during the past ten years, through the advent of chain-reacting atomic piles, that neutron sources of sufficient intensity have enabled the technique to become of practical importance. Since, in contrast to X-rays, neutrons are scattered by nuclei instead of the electron clouds of atoms, neutron diffraction studies provide information about structure and the solid state that is complementary to the results of X-ray diffraction investigations. This point is particularly emphasized by the author in the present book.

The chief centres of active work in the field of neutron diffraction have been in Great Britain at the Atomic Energy Research Establishment, Harwell, and in the United States at the Oak Ridge National Laboratory, Tennessee, respectively. Many pioneering investigations in the subject have been carried out by the author himself at Harwell, and this first-hand account from so experienced a practitioner is most welcome. This is indeed the first general treatment in book form, though an excellent article by the author and Prof. Kathleen Lonsdale appeared in the 1953 "Reports on Progress in Physics", published by the Physical Society.

The chapters fall naturally into two groups. The first six chapters cover physical principles, experimental methods, and the derivation of the fundamental data required for structure investigations. In the chapter on experimental techniques, we are given a good insight into many of the special problems that have to be solved: for example, those of obtaining a monochromatic beam, of choosing the optimum size of specimen, and of recording the diffracted beams.

The second part, comprising seven chapters, deals with applications and is perhaps of most interest to the general reader. There is an instructive survey of the unique way in which the technique enables light atoms such as hydrogen to be located in structures where the X-ray method fails to give a solution. The author's own contributions to the development of Fourier synthesis technique, in clarifying details of the structure of potassium dihydrogen phosphate, for example, are described. Not the least of the achievements of neutron diffraction has been in the solution of structural detail in ferromagnetic and antiferromagnetic substances, and two chapters are devoted to this fascinating subject. Short chapters are included on small-angle scattering and diffraction by liquids and gases.

Some information valuable for reference purposes is presented in tabular form. Neutron and X-ray scattering data for the elements and isotopes are compared in Table 2, while the relations between the absorption characteristics of neutrons and X-rays are listed in Table 6. An interesting table on pp. 160–161 compares the properties of X-rays and neutrons for diffraction studies.

There are very few misprints or errors in the text, and the book is well bound and of a convenient size. The subject is a rapidly advancing one, papers reporting new developments appearing regularly month by month. It is therefore valuable to have this authoritative survey of the achievements to date. It should make a wide appeal to all those interested in the furtherance of knowledge about the solid state.

H. P. Rooksby

NEW LIGHT ON AN OLD POLYMER

Cellulose Nitrate

The Physical Chemistry of Nitrocellulose, its Formation and Use. By Dr. Frank Douglas Miles. Pp. xiii+422+4 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1955. Published for Imperial Chemical Industries, Limited.) 45*s*. net.

THE theoretical and experimental background necessary for the understanding of high polymers is almost contemporary; the treatise of Staudinger was only published just over twenty years ago, and the modern entropy theory of their solutions is more recent still. Yet many of these substances, including nitrocellulose, have been major industrial products for a century or more. Workers in this field have therefore long felt the need for a treatise discussing, criticizing and interpreting, from a modern point of view, the great mass of experimental data and practical experience which has been acquired.

The treatise of Dr. F. D. Miles fulfils this need. His first chapter presents the X-ray and optical data on cellulose itself, and his second discusses the reaction of cellulose with nitric acid. Chapters 3–6 discuss the properties and applications of solid nitrocellulose and its gels (celluloid, leathercloth, cordite, etc.), and, finally, the last four chapters discuss the reactions of solid nitrocellulose, its fractionation, the properties of dilute solutions and the problem of solubility. The plan of the work is logical and orderly: the only criticism that can be made is that the presentation of data on solvent absorption and gelatinization in the fourth chapter, while the dilute solutions and general solubility are kept to the end, tends to hide their essential continuity.

In detail this book succeeds very well in holding the delicate balance between the old school who regarded such solutions and gels as uninterpretable except by special 'colloid-chemical' concepts, and the modernists who might consider there was nothing left to explain; in particular, Dr. Miles makes clear the importance of specific interactions between nitrocellulose and solvent molecules, although the last chapter does not tackle the difficult problem of the thermodynamic consequences of such interactions. The literature is very well covered—the long series of papers from government research establishments in France are given their proper importance, and Dr. Miles makes public for the first time much interesting work done in the laboratories at Ardeer of Imperial Chemical Industries, Ltd. It would be impossible in any reasonably sized book to discuss all the literature on nitrocellulose: Dr. Miles has managed to include nearly all the important papers before 1954 and at the same time to exclude the enormous volume of unsound work which, before his treatise, had to be ploughed through by those new to the subject.

This book can therefore be recommended to all interested in work on high polymers, as well as to those who specialize on cellulose and its derivatives. The book is well printed, and, for what it contains, is very cheap.

FURTHER STUDIES OF LAVOISIER'S CHEMICAL DISCOVERIES

Lavoisier

Théoricien et Expérimentateur. Par Maurice Daumas. (Bibliothèque de Philosophie Contemporaine, Logique et Philosophie des Sciences.) Pp. ii+180+4 plates. (Paris: Presses Universitaires de France, 1955.) 700 francs.

LAVOISIER has been the subject of many studies, but some details of his life and works are still imperfectly known. M. Maurice Daumas, who has studied correspondence, notebooks and other unpublished manuscripts preserved by the Paris Academy of Sciences, has re-examined several aspects of Lavoisier's chemical works, and the present book will be of value to all who are interested in eighteenth-century chemistry.

A chronological account of Lavoisier's work bearing on the theory of combustion, which has been compiled from many sources, shows that important results were often read to the Academy long before they were printed. The controversies over oxygen and water are briefly discussed, and it is concluded that Lavoisier did not himself claim priority for either the isolation of oxygen or the combustion of hydrogen to form water, but that he did, with justice, claim priority for the correct interpretation of the experiments. Many readers will agree with M. Daumas that sentiment rather than impartial inquiry has led to some opinions previously expressed on these topics.

M. Daumas also examines the origins of Lavoisier's "Traité Élémentaire de Chimie" (1789), showing that it was first planned in 1780 or 1781, before the antiphlogistic theory was complete; and he gives an interesting account of Lavoisier's apparatus, much of which still exists. The accuracy attainable by a scientist is limited by the quality of his apparatus as well as by his personal skill, and it was fortunate that Lavoisier could employ such excellent instrument-makers as Mégnié and Fortin.

After discussing Lavoisier's views on the nature of matter and on chemical affinity, M. Daumas concludes that, despite his genius, he could "act and think only as a man of the eighteenth century". However, he also directs attention to Laviosier's ability to "understand what was the problem of the hour, and to pursue it to its resolution"; that is a rare quality which ensures greatness in any century.

W. A. Smeaton

DISTORTION OF THE *E* LAYER OF THE IONOSPHERE BY ELECTRICAL CURRENTS FLOWING IN IT

By Sir EDWARD APPLETON, G.B.E., K.C.B., F.R.S., A. J. LYON and Mrs. A. G. TURNBULL
University of Edinburgh

It has long been known that the *E* layer of the ionosphere varies, both diurnally and seasonally, in a fairly regular manner, in that its maximum ionization density, N_m, is closely dependent on the solar zenith distance, χ. In the earliest study of this region, for example, Appleton and Naismith[1] found that, for the seasonal variation of noon maximum ionization in south-east England, N_m varied as $(\cos\chi)^{1/2}$. Because of its substantially regular behaviour, we have selected the *E* layer as a subject for more detailed study, to ascertain how far its properties conform with those of an ideal ionized layer, as classically expounded by Chapman[2]. We have used, for this purpose, ionospheric data obtained by radio sounding from stations now operating all over the world.

Chapman's well-known theory of ionized layer formation is based on two simple specified assumptions: the earth's atmosphere is considered to be isothermal, and the process by way of which electrons disappear is taken to be that of recombination. A further tacit assumption is that there is no movement of ionization, electrons appearing, and eventually disappearing, at the same point in space.

We began our investigation by attempting to make a careful comparison of the actual diurnal variation of N_m in the *E* layer with that predicted by Chapman's theory. It can readily be seen physically, and indeed is an essential result of the theory, that, due to the effects of recombination, the temporal variation of ionization density in a given layer lags slightly behind the corresponding variation of the rate of electron production. Thus the day-time maximum value of N_m is expected to occur after noon; while afternoon values of N_m are expected to exceed their corresponding forenoon values. Two well-known theoretical methods of finding the value of the recombination coefficient α are, in fact, based respectively on these two effects. For example, Appleton[3] has shown that the time delay Δt of the maximum of N_m relative to noon is given by $(2\alpha N_m)^{-1}$; so that, if the delay is measurable, α can be determined, since N_m is known. The other method of determining α is a little more complicated, but depends essentially on the determination of ΔN_m, the difference between afternoon and forenoon values, for local times equally spaced relative to noon. Using the great wealth of ionospheric data available for the Slough station, we have used both the Δt and the ΔN_m methods of finding α, from the diurnal asymmetry of the *E* layer. The results obtained are very remarkable in indicating extremely large variations of the *apparent* values of α. Our problem has therefore been that of deciding whether, in fact, α really does vary in such a remarkable fashion or whether the basic theory used is inadequate. In the latter case, if there were some additional perturbing factor operative, one might hope that, as often happens in such cases, the magnitude and nature of the discrepancy between theory and experiment would lead to the identification and measurement of the disturbing influence. As we shall see, such a hope has been, to a considerable extent, realized.

By extending our studies of the diurnal variation of N_m to a range of latitudes other than that of Slough, we soon found evidence indicating that the values of *apparent* α obtained by the methods used could not possibly refer to the true recombination coefficient and were in fact being influenced by a perturbing factor. For example, while stations in the higher latitudes behaved like Slough, in that Δt and ΔN_m were both found to be positive there, stations situated in a belt centred on the equator exhibited an inverse phenomenon, in that Δt and ΔN_m were found to be negative. Evidently, then, for stations in low latitudes, the influence of the perturbing factor is so great that it can actually reverse the sign of the diurnal asymmetry and cause afternoon values of N_m to be less than the corresponding forenoon values.

We were therefore led to examine afresh the whole basis of the theory of ionized layer formation, taking into account the possible influence of a likely perturbing factor. Now Chapman's theory is based on the simple continuity equation

$$\frac{dN}{dt} = q_0 \cos\chi - \alpha N^2 \qquad (1)$$

where N is the electron density, q_0 the rate of electron production when the sun is vertical, and t the time. If, however, we wish to take account of the possibility of electron transport phenomena, (1) must be written

$$\frac{dN}{dt} = q_0 \cos\chi - \alpha N^2 - \mathrm{div}\,(Nv) \qquad (2)$$

where the term div (Nv) expresses the electron transport-rate out of the unit volume under consideration. Now, as Martyn[4] has suggested, vertical drift of neutral ionization is a type of electron transport likely to occur in the ionosphere; and Appleton and Lyon[5] have developed the Chapman theory so as to allow for the effects of such drift under conditions applicable to the *E* layer. The theory of Appleton and Lyon is, moreover, formulated directly in terms of the value of N_m for a given layer, which is the quantity with which we are directly concerned in practice. From a practical point of view we are concerned with two effects of any vertical drift which may be operative, namely, the *alterations* it provokes in both the atmospheric level of the layer maximum electron density and in the magnitude of the maximum ionization density itself. We shall refer to these two departures from normality as $\delta h(N_m)$ and δN_m, respectively. The appropriate expressions for these quantities, given by Appleton and Lyon, are as follows:

$$\delta h(N_m) = \frac{v}{2\alpha N_m} \qquad (3)$$

and

$$\frac{\delta N_m}{N_m} = \frac{-\dfrac{\partial v}{\partial h}}{2\alpha N_m} - \frac{1}{4H^2}\left(\frac{v}{2\alpha N_m}\right)^2 \qquad (4)$$

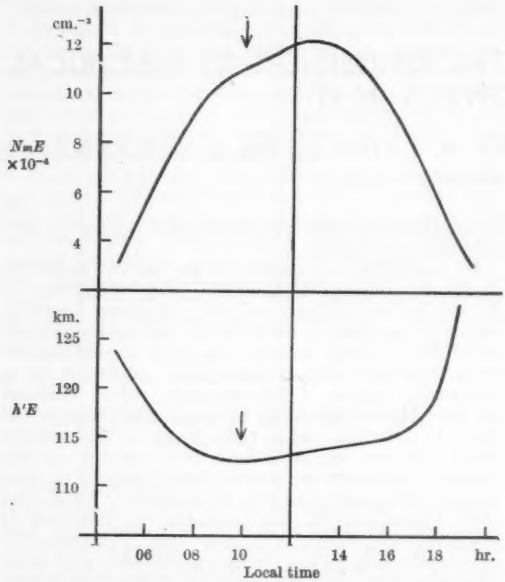

Fig. 1. Showing (upper curve) diurnal variation of Slough E layer maximum ionization density, N_m; and (lower curve) diurnal variation of Slough E layer height, $h'E$. In both cases abnormal variations (depressions) are to be noted in the forenoon when the ionospheric S_q currents attain their maximum intensity

where v is the velocity of vertical drift, $\frac{\partial v}{\partial h}$ is its vertical gradient (both measured positive upwards) and H is the scale height of the atmospheric ionized component responsible for the E layer. Equations (3) and (4) tell us, then, the corrections to the Chapman theory which are necessary to take vertical drift into account.

Now in looking for the possible intervention of vertical drift effects as a perturbing factor, we are naturally led to consider the S_q overhead current system, which is responsible for the daily solar magnetic variations, as a likely origin, since there is ample evidence that this current system flows at or near the level of maximum ionization in the E layer. We were additionally encouraged to do this since it is known that the S_q currents flow in opposite directions in high and low numerical latitudes, and, as described above, our study of E-layer diurnal abnormalities suggests the intervention of some perturbing agent which has opposite influences in high and low latitudes. Now it is an important characteristic of the S_q system that the overhead currents constituting it attain their maximum value, not at noon, but at about 1000–1100 h. local time. We were therefore led to look carefully for any abnormalities in $h(N_m)$ or N_m at that period of the day, in view of equations (3) and (4). Unfortunately, values of $h(N_m)$ were not available, so we were obliged to use values of $h'E$, the height of the under-boundary of the E layer, instead.

In Fig. 1 are shown the diurnal variations of $h'E$ and of N_m for Slough over the summer months of the year. On the same diagram is marked the approximate local time when the overhead S_q current (and the corresponding value of the horizontal north-seeking magnetic force, X_q) reach their maximum value. It will be at once apparent that, at this particular local time, the value of $h'E$ is abnormally decreased, while the value of N_m is similarly reduced. These results, we therefore submit, indicate that the S_q current system can markedly influence E layer phenomena and encourage us to count such an agency as likely to be one of the major perturbing factors responsible for the divergences we have identified between E layer behaviour and the Chapman theory.

We may first note a very simple result of electrodynamical theory. Since, at Slough, the S_q current flows from east to west, athwart the northwards horizontal component of the earth's magnetic field, we should expect the velocity of drift to be downwards; and, as equation (4) indicates, we should then expect the height of the layer (as measured by $h(N_m)$ or $h'E$) to fall in sympathy. We note that the abnormal variation of $h'E$, at the time of maximum overhead east-to-west current, has just the sign to be expected. It is, however, a novel result, which could not have been predicted, that δN_m and $\delta(h'E)$ are of the same sense. Since only the first term on the right-hand side of (4) is of numerical significance here, we can deduce, from (3) and (4) together, that v and $\frac{\partial v}{\partial h}$ are of opposite sign. In other words, we find that, when the S_q current flows from east to west, both the velocity of drift and the layer-height variation are downwards; while at the same time the drift velocity falls off with increasing height, leading to a reduction of the layer-ionization maximum N_m. We have now only to assume that all these ionospheric changes are reversed in sense in low latitudes (where, as we know, the S_q current flows from west to east) to be able to explain the E layer anomalies mentioned above. In low latitudes, for example, due to the fact that the S_q current system is not situated symmetrically to the local noon meridian, the E layer is subject to vertical drift effects which are different in the forenoon and afternoon. Such vertical drift causes a marked enhancement of N_m in the forenoon, which so far disturbs the natural diurnal asymmetry of N_m as to cause both Δt and ΔN_m to become negative, instead of positive, as simple theory would require.

Now although the S_q system of overhead currents is not situated quite symmetrically with respect to the noon meridian, its influence is generally exerted in the same sense over practically the whole of the middle of the day. Our study of abnormal diurnal asymmetry in N_m, as described above, shows that a west-to-east S_q current tends to raise the value of N_m, while an east-to-west S_q current tends to reduce it. We can therefore see that the overall effect of such an agency of vertical drift is to influence the general level of N_m in different ways in different latitudes; in low latitudes N_m is increased, at the latitude of the S_q current focus N_m is sensibly unaltered, while in still higher latitudes N_m is decreased. We are therefore encouraged to consider whether this simple general result, obtained from a study of the abnormal diurnal behaviour of the E layer, also explains any of the other abnormal features of the E layer which have been described in recent years.

Now Appleton[6] has shown that, while the value of N_m in the E layer is closely dependent on the solar zenith distance, it is not uniquely dependent on $\cos\chi$. There is, additionally, a tendency for the value of N_m to be high in low latitudes. For example, at the equinoxes, the contours of the geographical locations of constant N_m are not circles, with the sub-solar point as centre, as would be expected if

N_m were uniquely dependent on $\cos\chi$. They are, instead, of elliptical shape, the major axis lying along the equator. Again, in June and December at noon, it has been found that N_m does not attain its maximum value at the sub-solar point but at a latitude displaced therefrom by some 10° towards the equator. It will readily be seen that both these anomalies are also explicable in terms of a perturbation which, *ceteris paribus*, causes N_m to be greater in low latitudes than in higher latitudes. Moreover, a further study shows that these two anomalous features of *E*-layer morphology, namely, the abnormal diurnal asymmetry and the latitude dependence of N_m, are quantitatively reconcilable.

Finally, it may not be out of place to indicate what we consider to be the significance of these results in the general development of ionospheric studies. Many years ago it was boldly suggested by Balfour Stewart[7] that the daily rhythmic variations of the earth's magnetic field might be due to circulating electrical currents in the upper atmosphere. The geomagneticians then indicated the intensity and configuration of the upper-atmospheric current system which would be required. The discovery of the ionosphere and the elucidation of its properties by radio sounding has shown that the upper atmosphere is, in fact, sufficiently conducting to be the location of such currents; and the work now described has confirmed the presence of ionospheric currents, of the type prescribed, by way of the distortion they engender in the medium in which they flow.

[1] Appleton, E. V., and Naismith, R., *Proc. Roy. Soc.*, A, **150**, 685 (1935).
[2] Chapman, S., *Proc. Phys. Soc.*, **43**, 26 and 483 (1931).
[3] Appleton, E. V., *J. Atmos. Terr. Phys.*, **3**, 282 (1953).
[4] Martyn, D. F., *Proc. Roy. Soc.*, A, **180**, 241; **190**, 273 (1947); **194**, 429 and 445 (1948).
[5] Appleton, E. V., and Lyon, A. J., "Report on the Physics of the Ionosphere", p. 20 (The Physical Society, 1955).
[6] Appleton, E. V., Proc. Fourth Meeting Mixed Commission on the Ionosphere, p. 14 (1955).
[7] Stewart, B., "Terrestrial Magnetism", Encycl. Brit., Ninth Ed. (1882).

THE UNIVERSITY OF EXETER

By Prof. HUBERT T. S. BRITTON
Professor of Chemistry

ON October 28 the granting of the Royal Charter, reconstituting the former University College of the South West as the University of Exeter, was approved by an Order in Council at the meeting of the Privy Council, presided over by H.M. The Queen. The Charter appoints Mary, Duchess of Devonshire (widow of the tenth Duke of Devonshire) as the first chancellor of the University of Exeter; Mr. B. G. Lampard-Vachell, deputy president of the College, as a pro-chancellor; and Dr. James W. Cook, principal of the College and formerly regius professor of chemistry in the University of Glasgow, as the first vice-chancellor.

This marks the culmination of the struggle to make Exeter the centre for higher education which began so far back as 1861, when Sir Stafford Northcote (later the Earl of Iddesleigh) outlined his proposals for education at a meeting in Exeter in which he stressed the importance of making the city, "for which I believe it has natural and acquired advantages, a centre of Education for the West". A considerable sum was raised by subscription for the provision of premises for such an institution, and in 1862 a meeting was held to consider how this money could best be used to establish a memorial to the Prince Consort. It was decided that the memorial should be a museum with adjuncts for the study of art, science and literature, and the comments made by the Earl of Devon were prophetic in that the memorial would "continue to future generations the special benefits for which the person to be honoured had in his lifetime devoted himself". In 1865 the erection of the Royal Albert Memorial was begun, and in it evening classes were held in preparation for the Science and Art Department examinations of South Kensington, and there were also extension lectures given under the auspices of the University of Cambridge.

This type of education developed, and a full-time principal, Mr. A. W. Clayden, was appointed in 1894, a part of his salary being paid by the Local Lecture Syndicate of the University of Cambridge. Extensions of the Royal Albert Memorial became necessary, and one of these was opened in 1895 by the Duke of Devonshire, chancellor of the University of Cambridge. In 1897 the foundation stone of yet another extension, known to-day as the York Wing, was laid by the Duke of York, later King George V. This is the only part of the Memorial Building that is still used by the College, the rest being occupied by the Museum, Art Gallery and College of Art.

The session 1901–2 was notable in the history of the College, for it was then that courses were first devised to prepare some students for the London external degrees of B.A. and B.Sc., and in that year the College was recognized as a day training college for women, Mr. Clayden then becoming principal of the Royal Albert Memorial Museum, Library and College. In 1903 the College was recognized as a day training college for both men and women.

In 1904 the Exeter City Council sought the advice of Prof. (later Sir) Michael E. Sadler, of the Victoria University of Manchester, on the best way of co-ordinating and developing the educational work of the City, and in his report he stated that "Exeter is the educational metropolis of the west", and ended by asking the question, "Can we feel surprise, therefore, that the Royal Albert Memorial College shows many signs of its capacity to become the University College of the West". He records that in July 1904 there were four students preparing for final B.A. and B.Sc., seventeen for intermediate arts and science, thirty-six for London matriculation, eight for preliminary medical examinations and a hundred for the teachers' certificate of the Board of Education.

The College grew and by 1906 more spacious premises were required, and they are the buildings now occupied by the Arts Faculty. Whereas the cost of the original buildings was defrayed almost entirely from public subscriptions made by people living in Devon and Exeter, the cost of this building (£25,000) was met by the City of Exeter, except for a contribution of £6,400 made by the Board of Education.

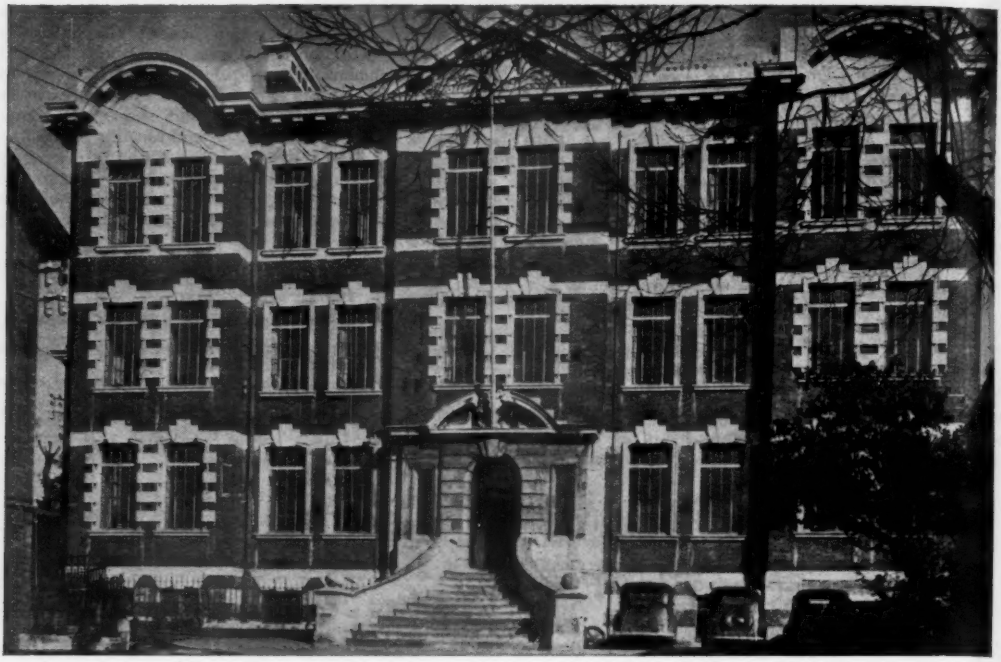

Fig. 1. University of Exeter: the Arts Faculty Building, Gandy Street

At this time the College was in straitened financial circumstances, and in 1912 an appeal for £30,000 for an endowment fund was launched; but the target was not achieved owing to the outbreak of the First World War.

In spite of repeated objections which were raised by the Board of Education, the City Council adopted the designation Royal Albert Memorial University College in 1908; but it was not until 1918 that it was recognized *de facto* as a university college, though it was not actually placed on the University Grants List of the Treasury until July 26, 1922. Principal Clayden (died 1944) retired in 1920 and was in April of that year succeeded by (later Sir) Hector J. W. Hetherington, who came from University College, Cardiff, where he had been professor of philosophy. He resigned in December 1924 to take the chair of philosophy at Glasgow, later to become vice-chancellor of the University of Liverpool, and is now vice-chancellor and principal of the University of Glasgow.

In its first two principals, University College, Exeter, has been twice blessed. Clayden was a man of vision who realized the need for university education in the south-west of England, and Hetherington, believing that the need was real, was able to persuade the Treasury to include the College at Exeter in the list of university institutions. In 1915, in his presidential address to the Devonshire Association, Principal Clayden forecast a University for the South West and described what he considered to be the scope of the University. Now that the University has become a reality, no doubt serious consideration will be given to his ideas.

From the time of its incorporation, the University College increased in numbers of students and staff and in academic attainment, due in no small measure to a succession of enthusiastic and energetic principals. They were Sir Walter Moberly (1925), who left in 1927 to become vice-chancellor of the University of Manchester, Dr. John Murray (1926–51), Prof. F. H. Newman (acting 1951–52), who died suddenly in 1952, Prof. S. H. Watkins (acting 1952), Sir Thomas Taylor (1952–53), who died suddenly in 1953, Prof. H. B. Garland (acting 1953–54), and the present vice-chancellor, Dr. James Wilfred Cook. The untimely deaths of Prof. Newman and Sir Thomas Taylor caused the submission of the petition for the grant of university status to be delayed until after Dr. Cook had assumed the office of principal.

The first president of the University College of the South West was H.R.H. the Prince of Wales; but on his accession to the throne as Edward VIII, Sir Henry Lopes (later Lord Roborough) was elected to that office, which he held until his death in 1938. Lord Cranborne (now Lord Salisbury) then became president, and it is a disappointment that, owing to the pressure of his other obligations, he was unable to allow his name to go forward as the first chancellor of the University of Exeter, towards the creation of which he has done so much.

Among the College benefactors may be mentioned Mr. E. J. Mardon, the late Lord Roborough, the late Mr. Washington Singer, the late Mr. C. V. Thomas, the late Mr. A. C. Ballard, the late Sir William Reardon-Smith, and the late Alderman W. H. Reed, at one time Mayor of Exeter. It was he who in 1922 gave to the College, Streatham Hall, a large mansion built in the Italian Renaissance style and now renamed Reed Hall, with its beautiful gardens and arboretum of eight acres, in the hope that the College would purchase the surroundings fields of more than a hundred acres to form the campus for the Univer-

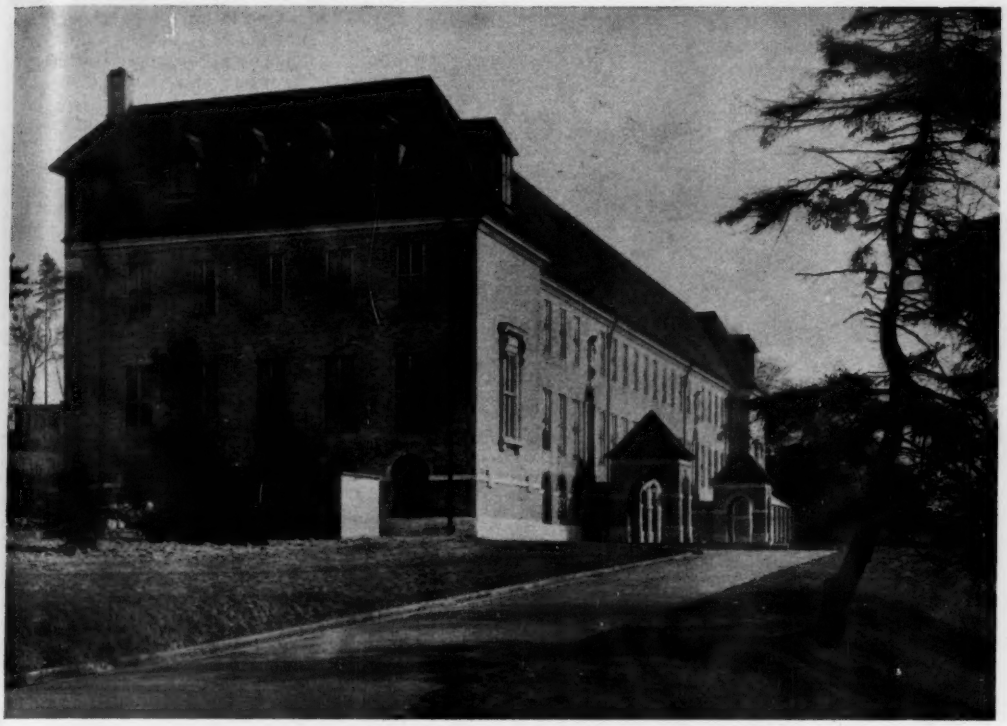

Fig. 2. University of Exeter: Washington Singer Laboratories

sity. It is that prevision which has placed the University of Exeter in such a pleasant setting.

Exeter is an ideal seat for a university. Several of the newer buildings of the University already occupy prominent positions on the University campus at Streatham, consisting of some 150 acres, which for beauty is probably unsurpassed by that of any other university institution in the United Kingdom. Its natural beauty is enhanced by the panorama of the varied Devonshire landscape that is to be seen from its slopes. It is situated about a mile north-west of the old buildings.

The original buildings are almost within a stone's throw of the Cathedral. Before the First World War they and the York Wing housed the entire College; but afterwards increased accommodation had to be found. This took the form of several rather unsightly ex-army huts, some of which were destroyed in the air raids of 1942. In 1931 the congestion in the Gandy Street buildings was partially relieved by the removal of the Departments of Chemistry and Physics to the new Washington Singer Laboratories on the University campus; but further relief did not come until 1939, when the library was transferred to the new Roborough Library, and again in 1953 when the Botany, Zoology and Geology Departments migrated to the new Hatherly Laboratories (see *Nature*, **171**, 860; 1953). In consequence, it was found possible to allocate a few rooms in the old building to the Guild of Undergraduates; but there still remains a real need for more space for the social requirements of the students.

The increase in the numbers of students reading, and carrying out research, in chemistry and physics renders imperative the need for additional accommodation. The Roborough Library is filled almost

Fig. 3. University of Exeter: Roborough Library

Fig. 4. University of Exeter: Reading Room, Roborough Library

to capacity with nearly 100,000 volumes. The erection on a rather elevated site of a new block for the Faculty of Arts is imminent. The architect of the Singer and Hatherly Laboratories and the Roborough Library and two Halls of Residence, Mr. E. Vincent Harris, is giving the University a chapel, to be known as the Mary Harris Memorial Chapel. Building will shortly begin.

Situated still higher on the southern slope of University campus are the Mardon and Reed Halls of residence for men, while on the top of the hill, which since the War has been levelled, is located a large playing field. By its side is the Taylor Pavilion —a memorial to the late principal, Sir Thomas Taylor. The facilities for sport have just been extended by the erection of a boat-house at Countess Weir on the bank of the Exe canal.

Contiguous with the campus is Knightley, in which the Faculty of Law and the Overseas Students' and Extra-mural Departments are housed, and Thornlea, which, together with a new building close by, accommodates the Department of Education and Psychology and the Institute of Education.

An important policy of the College was to make it residential so far as possible, and in the years immediately prior to 1946 this aim was almost realized; but since then, despite substantial efforts made by the College to acquire suitable premises, the influx of students has made it necessary for some to live in private lodgings for a part of their stay in Exeter. Of the 1,029 full-time students, who come not only from the south-west of England but also from London and elsewhere in England and Wales and from many overseas countries, 558 live in College halls and the remainder live either at home or in lodgings.

Since its incorporation as a University College, remarkable strides have been made in the training provided for the London external degrees in arts, science, economics and law. The number and quality of the degrees obtained serve as an indication of the high academic status which has been attained. Nor has this progress been confined to undergraduate training, for considerable attention has been given to postgraduate training and research. In the sciences, research has been a strong feature, as may be seen from the number of original papers published in the scientific journals and the number of Ph.D.'s which have been gained by Exeter students. Facilities for research in astronomy are also available in the Norman Lockyer Observatory at Sidmouth, which for many years past has been closely associated with the University College. On the arts side, abundant material for investigation has been rendered available to the students by the recent agreement of the Dean and Chapter of the Cathedral to entrust the College Librarian with the care of the unique library of the Cathedral.

For the time being, the University of Exeter will develop and consolidate its existing Faculties of Arts (including Education), Science, Social Studies (including Economics, Social and Public Administration) and Law. Nevertheless, it is safe to say that the possibility of extending its usefulness in other fields of learning and research will always receive the constant vigilance and attention of the new University. Its aspirations and aims will always be to serve mankind, the United Kingdom and especially the inhabitants of the south-west of England.

INTERACTION OF SPRAY PROGRAMMES AND INSECT POPULATIONS

An open day at East Malling Research Station on September 21 provided an opportunity for some two hundred members to hear and discuss contributions by staff of the Entomology and Plant Protective Chemistry Sections on the interaction of spray programmes and insect populations. Following the usual custom, members of the official advisory services attended a similar programme on the previous day.

It was pointed out that the present investigations, which are devoted to a study of the fruit-tree red spider mite, *Metatetranychus ulmi* (Koch), its natural enemies, and the effect of spray chemicals on populations of both, are a collaborative project shared by entomologists, plant-protective chemists and plant pathologists. The entomologists are primarily concerned with the biological and ecological problems involved, the chemists with the mechanism of action by which the spray materials in common use affect the insects and mites and, since there is ample evidence to show that fungicides as well as insecticides sometimes prove harmful to the beneficial fauna, the plant pathologists also become intimately involved in such a project. At the present time only a progress report is possible; the causes leading to the appearance of *M. ulmi* as a pest are fairly clear,

but much detailed work lies ahead before a spray programme can be devised by which beneficial insects are retained in the fruit plantation while pests and diseases not amenable to control by natural agencies are kept in check by the application of chemicals.

Historically, *M. ulmi* has been noticed as a pest in English orchards only during the past thirty years, its appearance coinciding with the use of tar distillate washes which became general from 1925 onwards. More recently, infestations have been accentuated following the use of DDT and parathion as post-blossom sprays and, in some Kent and Essex apple orchards, the red spider mite, *Tetranychus telarius* L., has appeared as a pest for the first time following frequent applications of parathion during the summer months. Examples such as these clearly indicate that harmful side-effects may arise from the use of new spray chemicals; and since such materials are often in the hands of growers before members of research institutions have time to evaluate their full effects on the orchard fauna, it is only prudent for them to be used on a small scale at first, followed by close and frequent observation, so that remedial measures can be taken at the earliest moment should the need arise.

As a result of intensive surveys in both sprayed and derelict orchards, about a hundred species, comprising approximately equal numbers of insects, and spiders and mites, have been found that utilize in varying degrees *M. ulmi* as a source of food. Striking differences occur between the fauna of these two orchard types. In derelict orchards a large number of species occur, forming a continuous succession, so that predators are represented in strength throughout the year, attacking the mite during the whole of its active period and also feeding on the winter eggs. In sprayed orchards there is usually a total absence, or at least a very marked reduction, of predators until June; for the remainder of the summer the species are much fewer, although individual insects such as the black-kneed capsid, *Blepharidopterus angulatus* (Fall.), are often present in considerably greater numbers than in unsprayed orchards. Only minor annual fluctuations of both species and total populations occur in the derelict orchard, whereas both show violent variations in the sprayed orchard. In part this can be accounted for by the direct effect of sprays, but alternative sources of food, other than phytophagous mites, readily available only in derelict orchards, must also be an important contributory factor.

Among the insect predators, those occurring most commonly include species of Miridae (*Psallus ambiguus* (Fall.)), *Campylomma verbasci* (M.-D.), *Atractotomus mali* (M.-D.), *Orthotylus marginalis* Reut., *Phytocoris* spp., *Malacocoris chlorizans* (Panz.), *Blepharidopterus angulatus* (Fall.)), Anthocoridae (*Anthocoris nemorum* (L.), *Orius majusculus* (Reut.)), Coccinellidae (*Stethorus punctillum* (Wei.)) and Coniopterygidae (*Conwentzia* spp.). Of the spiders, only members of the families Theridiidae and Linyphiidae readily feed on *M. ulmi*; and the predacious mites are predominantly species of the genus *Typhlodromus*, of which only *T. tiliae* Oudms. becomes abundant in sprayed orchards.

The relative importance of each predator has not yet been fully assessed; but field observations indicate that all the insects named possess the desirable character of being 'density dependent' in the sense that numbers increase in the presence of ample food, whereas the spiders, with at most one generation a year, increase their rate of feeding when food is plentiful. The latter group attack both beneficial and pest species indiscriminately, and are therefore of doubtful value except under conditions where the pest predominates. Judged by the usual standards, *Typhlodromus tiliae* is an inefficient predator, as its behaviour pattern both in respect to leaf preference and position on the leaf is not well integrated with that of *M. ulmi*; furthermore, it has a low feeding capacity and can develop and reproduce on plant protein or other species of mites.

As an introduction to the orchard trials in progress at East Malling, the effects arising from two extreme ecological situations were described in very simplified form. In one example, a succession of natural enemies present in the same environment as the prey and attacking it throughout its life-cycle resulted in a continuous depression of prey population similar to that already observed in connexion with *M. ulmi* in derelict orchards. But under such conditions alternative sources of food are necessary if predator populations are to be maintained. As yet, relatively little is known about this aspect; but experiments have demonstrated that the Mirids and Typhlodromid mites are partly phytophagous, and it is also clear that the much richer fauna, including pest species such as aphids and *Psylla mali* Schmid., occurring in the unsprayed orchard, can provide adequate food for the predators. In contrast to the above, the violent oscillations associated with the presence of only a single species of predator and prey were outlined. Examples of this type are rarely documented in Nature except in specialized ecological niches, but it appears that man may have created such a situation in sprayed orchards between *M. ulmi* as prey and *B. angulatus* as predator. A composite picture from the records of two experimental orchards over the past three years has shown one complete oscillation, two stages of which were available as a visual demonstration. In one orchard, where the population of *M. ulmi* was approaching its peak and predator populations were increasing annually but not yet large enough to cause suppression, the foliage was markedly bronzed, whereas in another orchard, where mite populations suffered a severe reversal in 1954, the fresh green foliage bore no evidence of injury, even in the absence of any acaricidal sprays.

Investigations concerning the effect of spray chemicals on populations of *M. ulmi* and its predators are still in the analytical phase, being concentrated on elucidating the harmful effects of insecticides in general use during the pre-blossom period, together with a similar study of fungicides when applied throughout the spraying season. Sufficient data have been obtained to demonstrate that, by ovicidal or contact action, DNC(dinitrocresol)-petroleum applied at the delayed dormant stage destroys practically all the predators which would normally be present before June; DDT, by contact or residual action, has a similar effect when applied at the mouse-ear stage; lime-sulphur drastically reduces Typhlodromid mites and causes a slight reduction of Mirids. Studies of the age structure of certain Mirid species following the use of captan (*N*-trichloromethylthio-*cyclo*hex-4-ene-1 : 2-dicarboxyimide), a fungicide considered non-toxic to these insects, have indicated that even the physical effect of sprays applied at high pressure by the conventional hydraulic equipment may seriously affect predator populations.

The very harmful effect on beneficial species of certain insecticides used for controlling pests during the pre-blossom period has therefore been clearly demonstrated; it can also be deduced from indirect evidence that chemicals in current use against the apple sawfly, *Hoplocampa testudinea* Klug, will produce similar results. In addition, it has been shown that the range of predators occurring from June onwards is unable to prevent large oscillations in the population of *M. ulmi*. The aim, therefore, is to modify the spray programme in order to allow the establishment of one or more efficient predators early in the season. Further advances along these lines will be largely dependent on the chemical studies now in progress concerning the fate of materials after deposition on the tree. By increasing knowledge in this sphere, it may be possible to achieve rather more selective action by choice of chemical and variations in its time of application, concentration or formulation.

METABOLISM OF NITROGEN IN PLANTS

A SESSION on the nitrogen metabolism of plants, under the chairmanship of Prof. M. Skene, was held at Bristol on September 2 by Section K (Botany) of the British Association. Problems of the assimilation of nitrogen and the synthesis of amino-acids and proteins in plant tissues formed one of the central themes of the discussion. Three speakers gave accounts of some of the work in progress in the Department of Botany of the University of Bristol, and Prof. H. E. Street (University College of Swansea) discussed the potentialities of the aseptic culture of excised roots as a means of studying the assimilation and metabolism of nitrogen.

The part played by different cellular structures in the synthesis of proteins was dealt with by Prof. E. W. Yemm (Bristol). Earlier views, derived chiefly from genetical considerations, have suggested that the nucleus is the most important centre of protein synthesis in the cell, and this hypothesis has been developed particularly by Caspersson. The conspicuous changes of nucleic acids associated with protein synthesis in some animal cells and in micro-organisms provide the chief support for the hypothesis. During recent years several lines of evidence have been advanced which are difficult to reconcile with the view that protein synthesis is entirely localized in or on the surface of the nucleus. For example, Brachet and his collaborators have shown that non-nucleated fragments of some plant and animal cells continue to synthesize proteins actively. In addition, experiments with isotopically labelled amino-acids indicate that they are rapidly incorporated into particulate structures of the cytoplasm. Ultramicroscopic particles, which may be separated by differential centrifugation and which contain most of the ribonucleic acid of the cytoplasm, are especially active in the incorporation of radiocarbon-labelled amino-acids. It has therefore been suggested that these cytoplasmic microsomes are the chief centres of protein synthesis in cellular metabolism.

There are, however, several difficulties in the interpretation of data based solely on the incorporation of labelled amino-acids into cell proteins. The study of proteinases and other plant enzymes has shown that they promote exchange reactions, such as transpeptidation and transamidation, so that replacement of amino-acids does not necessarily imply a new synthesis of protein. Experiments with detached leaves and roots of barley have shown that, even under conditions in which a net loss of proteins occurs in the tissues, there is nevertheless appreciable incorporation of the isotope nitrogen-15 into the cytoplasmic proteins. On the other hand, under conditions in which an active synthesis of new proteins occurs, such as in young seedlings, it is possible to detect the incorporation of nitrogen-15 into all the cell components separated by differential centrifugation within a few hours of supplying the isotope as an ammonium salt. The results so far obtained from a study of the assimilation of nitrogen-15 by barley seedlings suggest that the primary synthesis of new protein is not confined to microsomes but may also take place in nuclei, plastids and mitochondria of the cells.

Dr. A. J. Willis (Bristol) discussed the assimilation by plants of simple inorganic forms of nitrogen, such as nitrates, nitrites and ammonium salts, and gave an account of experiments in which an attempt was made to trace the early stages of the assimilation process and to determine the nature of the primary products formed in young roots of barley. Under conditions favouring a rapid uptake of nitrates, nitrites or ammonia by excised roots, it was found that a marked increase of glutamine, accompanied by smaller quantities of asparagine, occurred in the tissues. During short periods of assimilation more than 90 per cent of the nitrogen metabolized could be recovered as amides, chiefly glutamine. By using nitrogen-15 as a tracer it was possible to obtain decisive evidence that the amides were primary products of assimilation. When the roots were supplied with an ammonium salt containing about 30 atom per cent excess of nitrogen-15, the isotopic abundance in the amino- and amide-groups of glutamine rapidly approached that of the ammonia supplied. Some differences were apparent in the amount of amides formed when different sources of nitrogen were provided: nitrite and ammonia were more rapidly metabolized in the young roots than nitrate, the step nitrate to nitrite being a slow one. All the data support the hypothesis that nitrite, hydroxylamine and ammonia are intermediates in the assimilation of nitrate and that glutamine is a primary product of synthesis.

Other metabolic activities of the roots are closely associated with the assimilation of nitrogen. The rate of respiration, measured by the uptake of oxygen and the production of carbon dioxide, is greatly increased when a suitable source of nitrogen is provided. The most rapid responses are obtained with ammonia and nitrites, and there are many indications that the rise in respiration is coupled with synthetic activities in the tissues rather than with salt uptake. An extensive breakdown of carbohydrate sustains the assimilation processes in excised roots for a limited period, and analytical data indicate that both the respiratory carbon dioxide and the carbon skeletons for the synthesis of amides are mainly

supplied by glycolysis. Some recent evidence suggests that the close coupling between respiratory activity and the metabolism of carbohydrates and nitrogen may occur within the mitochondria, which appear to be the chief centres of the metabolism of glutamic acid and glutamine in the cell.

Somewhat similar experiments carried out on the assimilation of ammonium salts by food yeast (*Torulopsis utilis*) have given results in many respects similar to those outlined above. The rate of respiration and carbohydrate breakdown show a marked increase, while glutamine and glutamic acid, together with smaller amounts of alanine, have been identified as the chief products of assimilation accumulating at first in the cells. Here again, the key position of glutamic acid and glutamine in the assimilation of nitrogen is indicated.

The metabolism of amino-acids, and particularly their relation to protein synthesis, was discussed by Dr. B. F. Folkes (Bristol). In plant tissues, most of the nitrogen is combined in complex proteins which contain an array of some eighteen different amino-acids. Analyses of different proteins show that, although similar amino-acids are generally present, their proportions vary widely. This is particularly evident in the analyses of reserve proteins found in seeds and other storage organs, although the cytoplasmic proteins appear to be relatively constant in composition throughout the plant kingdom. A systematic study of the proteins of barley grains and their changes during germination has thrown some light on the metabolism of amino-acids in the young seedling.

With regard to the relation between amino-acids and protein synthesis in plants, two distinct types of hypothesis have been advanced: the so-called amino-acid hypothesis suggests that amino-acids are first formed and are then combined into the polypeptide structures of proteins; alternatively, it is suggested that proteins are synthesized by complex condensations of metabolites without the intervention of amino-acids. The results obtained from an investigation of the nitrogen metabolism in barley seedlings are consistent with the amino-acid hypothesis. If the grains are germinated without external supplies of nitrogen, the formation of new proteins in the embryo is entirely at the expense of the reserve proteins of the endosperm. Analyses show that 75 per cent of the amino-acids required for protein synthesis in the developing embryo could be derived direct from the endospermic proteins; but, on the other hand, certain amino-acids show large changes as germination proceeds. An increase of aspartic acid, alanine, lysine and arginine occurs at the expense of glutamic acid, amide and proline, which are present in large amounts in the reserve proteins. These results strongly suggest that glutamic acid and glutamine are the chief precursors in the synthesis of other amino-acids, and in this regard the data offer a close parallel to those obtained during the assimilation of external supplies of nitrogen. The presence of transaminases which promote the interconversion of glutamic acid and at least six other amino-acids has been demonstrated in young barley embryos. These and other enzymes which bring about the interconversion of glutamic acid and proline appear to occur mainly in the mitochondria, and the mechanisms underlying the transformation of amino-acids may in part determine the close relation between nitrogen metabolism and cellular oxidations.

Evidence from several other directions now gives support to the amino-acid hypothesis. It has been shown, for example, that isotopically labelled amino-acids may be incorporated into tissue proteins of plants and animals while, particularly in micro-organisms, amino-acids may act as specific nutrients. The close connexion between nitrogen metabolism and respiration in plants, which has generally been regarded as favouring the alternative hypothesis, can be more simply interpreted in terms of the synthesis and interconversion of amino-acids and the energy requirements of peptide formation.

In a discussion of the nitrogen nutrition of excised roots, Prof. H. E. Street directed attention to the advantages which may be gained from the use of aseptic organ cultures. Metabolic interrelations between the separate parts of the plant body may be studied, thereby enabling sites of synthesis to be identified. The aseptic conditions of culture permit critical feeding experiments with organic or inorganic forms of nitrogen under closely controlled conditions in which experimental responses can be assessed in terms of both biochemistry and growth. In addition, the use of clonal material, readily multiplied, ensures genetic uniformity. At the same time, excised organ culture can expose genetic characters obscured in work with whole plants, making available tissues with distinctive metabolisms.

Some of these potentialities are being exploited in current researches into the nitrogen nutrition of aseptically cultured excised roots. For the first time, experimental conditions have been defined for the growth of excised roots on nitrate, nitrite and ammonia. Ethylenediamine tetracetate at an appropriate concentration is used to ensure availability of iron, and sparingly soluble calcium phosphates and calcium carbonate are employed as buffers. In the media used, there are sharply distinct *p*H optima for growth with each different inorganic nitrogen source: *p*H 7·0–7·5 for ammonium, *p*H 4·3–5·0 for nitrate and *p*H 5·5–6·5 for nitrite. These optima do not seem to be explicable simply in terms of a direct effect of *p*H on either the absorption or assimilation of nitrogen.

Roots grown on different inorganic nitrogen sources show characteristic differences in the composition of their alcohol-soluble nitrogen. Ammonium roots are rich in ammonium, amide and free amino-acid nitrogen and low in 'other' or 'residual' nitrogen, the relative magnitude of these fractions being reversed in roots grown in nitrate. Nitrite roots contain nitrite nitrogen, but otherwise resemble ammonium roots in composition. When extracts are examined chromatographically, clear-cut differences, depending upon nitrogen source, are revealed in the range and relative amounts of the individual amino-acids present. These investigations are being extended to study the effects not only of nitrogen source but also of carbohydrate and mineral status on the nitrogenous composition. The influence on nitrate-reducing ability of prolonged culture of roots in ammonium nitrogen is being studied, and the nitrate-reducing abilities of excised roots from different species and genetic strains are being compared.

The growth of excised roots from certain species has been found to be markedly stimulated by amino-acids. For example, stimulations of growth of different geographical strains of excised groundsel roots are observed with amino-acids of the ornithine cycle. With the roots of other species, externally

supplied amino-acids are toxic. Individual amino-acids differ markedly in their toxicity, and in some instances the relations between toxicity and concentration are complex. Use of amino-acid mixtures has revealed 'amino-acid antagonisms', the mixtures being usually less toxic than their constituents. Very strong antagonisms have been shown between certain pairs of amino-acids of similar chemical structure.

Investigations of the nitrogen nutrition of excised tomato roots have revealed that dimethylaminoethanol, ethanolamine, glycine, choline and certain other nitrogenous compounds can replace the growth requirement of the roots for pyridoxine (vitamin B_6). These replacement effects throw some light on the part played by the vitamin in the metabolism of the roots and further illustrate the ability of the technique to expose new topics in plant physiology.

OBITUARIES

Dr. L. C. Thomson

The untimely death on October 10 of Lewis Charles Thomson in his forty-third year comes as a shock to his many friends and colleagues; for Thomson was a model of vigorous health, and the illness to which he succumbed was, mercifully, brief.

Thomson entered Guy's Hospital from Sherborne in 1932. As a medical student he gained several distinctions—the Hilton Prize for dissection in 1933, the Michael Harris Prize for anatomy and the Junior Proficiency First Prize in 1934—and held demonstratorships in histology, anatomy, bacteriology and pathology. He qualified M.R.C.S., L.R.C.P. in 1937, and M.B., B.S. in the following year.

While at the Hospital, Thomson held in succession the complete series of appointments from clinical assistant to house surgeon. But Thomson was not destined for an ordinary medical career. His interests were teaching and research. Consequently, in 1940, he joined the staff of the Medical School at Guy's, first in the Anatomy Department, and then, between 1942 and 1947, in the Department of Physiology.

During this period he worked on a number of problems, among which was the preparation of an inorganic solution which had an equal optical density for all wave-lengths within the visible spectrum (Thomson's Grey Solution). In after years he took pleasure in mystifying the uninitiated with this smoky-looking solution and was highly delighted if asked how the carbon was kept in suspension. His main contributions at Guy's, however, were to vision, and in 1948 he received his Ph.D. for a thesis on the part played by the nervous system in visual adaptation.

With such a background it was natural for Thomson to join, in 1947, the Vision Research Unit. This had just been formed at the Institute of Ophthalmology by Prof. H. Hartridge under the auspices of the Medical Research Council. In 1945, Prof. W. D. Wright had invited Thomson to collaborate on problems concerning the colour vision of small areas within the fovea. This fruitful association was continued after he had joined the Vision Research Unit and ceased only in 1951 when he assumed, on Hartridge's retirement, the directorship of the Unit, renamed the Group for Research in the Physiology of Vision.

In spite of his close attention to administrative detail, Thomson continued to prosecute his own researches with vigour, and at the time of his death had published more than twenty papers on visual topics. His more important contributions concerned the colour sensitivity and intensity discrimination of the central fovea, the influence of the light history of the eye upon the course of its dark adaptation, binocular summation within the nervous pathways of the pupillary light reflex, and the variations of hue discrimination with change of luminance level. Thomson also directed attention to the irregularities of shape in the equal-energy luminosity curve.

As a long-term project, Thomson had constructed apparatus for electro-physiological researches. He mastered the many technical problems involved in such work; but, just when it seemed that his labours were to be crowned with success, he had to lay down his tools. In the year of his death honours were coming fast to Thomson. He obtained his D.Sc. early in 1955; he delivered the twenty-seventh Ettles Memorial Lecture, and was to have been the first Edridge-Green Memorial Lecturer.

Thomson was a first-class administrator. He organized the British delegation to the Nineteenth International Physiological Congress in Montreal in 1953, and was chairman of the Colour Group of the Physical Society during 1953–55.

In spite of his intense pre-occupation with research and administration, Thomson had a number of other interests. He loved sailing, and navigated his boat across the North Sea and the Channel; he was also a keen photographer and an interested student of geology.

Thomson was a most likeable character; he was quiet, unassuming and possessed the rare blend of humility and steadfast purpose. He was a devout Christian and his life was guided by his deep religious beliefs. He will be sadly missed by his colleagues and friends. The deepest sympathy is extended to his widow, his two young sons and his widowed mother.

H. J. A. Dartnall

Mr. Alexander Gow

Alexander Gow, who died on October 13, in his eighty-seventh year, performed a noteworthy service to the cause of scientific and technological education in Great Britain by reason of his administrative work as the first secretary of the then newly constituted Imperial College of Science and Technology, serving during the period 1908–34, which bore the first fruits of the fusion of the three constituent colleges, the Royal College of Science, the Royal School of Mines and the City and Guilds College, into an academic unit. An aspirant to the teaching profession, he was educated at the Borough Road Training College and Caius College, Cambridge. His early appointments were scholastic, and he served as principal of the Municipal Technical and Secondary School, Warrington, and as director of education for Blackburn, before undertaking his *magnum opus*, the permanent value of which was signalized by his election to honorary fellowship of the Imperial College in 1946.

Then, as now, no secretary of a college could escape the continuous pressure on reserves of knowledge, of divination, of judgment, and even of sheer physical effort which a responsible share in the shaping of its educational policy exercises. So far as those then associated with him in a less authoritative position

could penetrate an exterior reserve, it appeared that Gow took such responsibilities easily in his stride. Always unruffled, precise, even pontifical in manner, he held in firm grasp the controls of a machine of steadily growing complexity, while maintaining excellent relations with those responsible for the direction of academic studies and from time to time disclosing the warmth of sympathetic understanding which characterized his unofficial relationships with fellow members of the College. He served under four rectors: Dr. Henry Bovey, Sir Alfred Keogh, Sir Thomas Holland and Sir Henry Tizard. During his retirement, in which until recently he continued to enjoy the devoted companionship of his wife, he retained his interest in the affairs of the Imperial College through occasional correspondence with his former colleague and successor in office. The expansion of the College, now in progress, rests on foundations well and truly laid by men among whose names that of Alexander Gow occupies a worthy place.

NEWS and VIEWS

Royal Society Medals: Awards for 1955

THE following awards of medals have been made by the President and the Council of the Royal Society:

Copley Medal to Sir Ronald Fisher, Arthur Balfour professor of genetics in the University of Cambridge, for his distinguished contributions to developing the theory and application of statistics for making quantitative a vast field of biology.

Davy Medal to Prof. H. W. Melville, Mason professor of chemistry in the University of Birmingham, for his distinguished work in physical chemistry and in polymer reactions.

Sylvester Medal to Prof. E. C. Titchmarsh, Savilian professor of geometry in the University of Oxford, for his distinguished researches on the analytical theory of numbers, and other branches of pure mathematics.

Hughes Medal to Prof. H. S. W. Massey, Quain professor of physics at University College in the University of London, for his distinguished contributions to atomic and molecular physics, particularly in regard to collisions involving the production and recombination of ions.

Royal Society of Edinburgh: Officers for 1955–56

THE following have been elected officers and members of council for 1955–56 of the Royal Society of Edinburgh: *President*, Prof. James Ritchie; *Vice-Presidents*, Dr. A. H. R. Goldie, Prof. C. M. Yonge, Prof. Norman Feather, Prof. J. Norman Davidson, Principal H. B. Nisbet and Prof. Meirion Thomas; *General Secretary*, Dr. J. E. Richey; *Secretaries to Ordinary Meetings*, Dr. T. R. Bolam and Dr. A. W. Greenwood; *Treasurer*, Mr. A. W. Young; *Curator of Library and Museum*, Dr. Douglas Guthrie; *Councillors*, Dr. J. M. Cowan, Dr. David Jack, Prof. J. M. Robertson, Prof. D. Whitteridge, Prof. E. M. Wright, Prof. E. L. Hirst, Dr. D. E. Rutherford, Dr. D. A. Allan, Prof. G. H. Bell, Dr. D. N. McArthur, Dr. A. G. MacGregor and Prof. C. H. Waddington.

Electrical Engineering at Birmingham: Prof. D. G. Tucker

DR. D. G. TUCKER, who succeeds Prof. A. Tustin at Birmingham (see *Nature*, 175, 148; 1955), has spent several years at the Post Office Research Station, where he was engaged on research and development work on telephone transmission, including the war-time development of special carrier telephone systems; in 1946 he was head of the Post Office Transmission Measurements Research Group. In 1950 he joined the Royal Naval Scientific Service at H.M. Underwater Detection Establishment at Portland, and he has resigned his post as a senior principal scientific officer at this Establishment in order to take the chair of electrical engineering in Birmingham. Dr. Tucker has had wide experience in telephone transmission research and in the development of very advanced types of under-water acoustic equipment. In addition, he has been engaged in applied research in electronics, acoustics, oceanography and operator problems. He holds the degrees of D.Sc.(Eng.) and Ph.D. in the University of London, and he has published a large number of papers dealing with electronic and transmission problems. He takes to Birmingham wide experience of applied research in the field of communications and electronics. In addition, he is a keen student of natural history, and he has published several papers on bird population studies in the *London Naturalist*, the journal of the London Natural History Society.

Foundry Metallurgy at the Massachusetts Institute of Technology: Prof. H. F. Taylor

A NEW chair, the American Brake Shoe Company chair of foundry metallurgy, has been established at the Massachusetts Institute of Technology, and Prof. Howard F. Taylor, already professor of metallurgy and director of the Institute's Foundry Laboratory, has been appointed its first holder. Prof. Taylor graduated in chemical engineering and metallurgical engineering at Michigan State College and went in 1937 to the Naval Research Laboratory in Washington, D.C., where he later became head of steel casting research. He joined the staff of the Massachusetts Institute of Technology in 1945 and in 1952 became a full professor. Partly in consideration of his work during the Second World War, Prof. Taylor was awarded the Peter L. Simpson Gold Medal in 1946 by the American Foundrymen's Society and the Army–Navy Distinguished Civilian Service Award in 1948. The American Brake Shoe Company, which has more than fifty plants and is one of the leading foundry companies in the United States, has supported metallurgical work at the Institute with grants-in-aid, a graduate fellowship and undergraduate scholarships. During recent years the Institute's Foundry Laboratory has been greatly expanded, and it now provides some of the best facilities for research in this field in the United States.

Zoology at Lucknow: Dr. M. B. Lal

THE Lucknow School of Zoology made great advances under the late Prof. K. N. Bahl (*Nature*, 174, 16; 1954), and good wishes for its continued progress will follow his recently appointed successor, Dr. Makund Behari Lal. Most of Dr. Lal's training has been at the University of Lucknow, where he

graduated M.Sc. in 1928 and D.Sc. in 1937, and where as demonstrator in zoology (1929) and lecturer in the Department (1937) he showed his ability as a teacher and research worker. At the end of the Second World War he went to Great Britain and spent two years in the Zoology Department of the University of Edinburgh, developing his knowledge of the life-histories of various helminths in order to further this line of investigation in India. He was awarded the D.Sc. degree of Edinburgh in 1947, and on his return to Lucknow was appointed reader in zoology. Recently he represented India at the General Assembly in Rome of the International Union of Biological Sciences. He was elected this year a member of the Zoology Committee of the Union. Dr. Lal's main line of investigation has been helminthological, but that has not prevented him from making useful contributions in other fields of invertebrate and experimental zoology. Under his conscientious care, zoology in Lucknow should continue to flourish.

Textile Institute

Honorary life membership of the Textile Institute, Manchester, has been conferred on Mr. Fred Scholefield, formerly head of the Department of Textile Chemistry, Manchester College of Technology, in recognition of the long and valuable services given by him to the Institute. Mr. Scholefield has been a member of its Examinations Board for twenty-five years, being chairman of the Board in 1938, and received the Institute Medal in 1951.

The first formal lecture to be given on the Continent of Europe under the auspices of the Textile Institute will be delivered by Mr. J. R. Whinfield at the Swiss Federal Institute of Technology, Zurich, on November 25. Mr. Whinfield gave the Emsley Lecture at Institute headquarters on October 14, and will speak on the same subject at Zurich, namely, "Textiles and the Inventive Spirit".

British Museum (Natural History): Appointments

The Principal Trustees of the British Museum have appointed Dr. George Taylor, keeper of the Department of Botany in the British Museum (Natural History), to be a deputy chief scientific officer on the retirement of Mr. N. D. Riley, who has held that office in conjunction with the keepership of entomology; and Dr. William Edward China to be keeper of the Department of Entomology in succession to Mr. Riley.

Dr. Taylor (who will continue to be keeper of the Department of Botany) entered the Museum in 1928 after graduating with first-class honours at the University of Edinburgh. During his service in the Museum Dr. Taylor has been concerned mainly with flowering plants, and has taken part in collecting expeditions to East Africa and Tibet. Apart from his Museum work, he is a general secretary of the British Association for the Advancement of Science and president of the Botanical Society of the British Isles, and takes an active part in the affairs of the Royal Horticultural Society.

Dr. China was a scholar of Trinity Hall, Cambridge, where he graduated with second-class honours in zoology in 1920 (Sc.D., 1948). He entered the Museum in 1922 and throughout his career has specialized on the Hemiptera–Homoptera (the 'true' bugs). He has published some two hundred papers on these insects and is general editor of the World Catalogue of Hemiptera (published in the United States).

Water Resources and Water Requirements in Britain

The Central Advisory Water Committee has decided to institute inquiries into the growing demand for water and into the collection of information about the water resources of Britain. It appointed members to form the nucleus of two sub-committees which will report back to the main committee; they have power to co-opt, so that the inquiries will be widely representative. The terms of reference of the sub-committees are: (*a*) Sub-Committee on the growing demand for water (*chairman*, Alderman R. C. Yates). "To consider the extent to which the demand for water for domestic, industrial, agricultural and other purposes is increasing and is likely to increase; to consider the problems involved in meeting these demands, including, in broad terms, the cost; to consider whether there are any substantial economies in the use or cost of water which could be made without reduction in standards of hygiene or in industrial or agricultural efficiency; and to make recommendations". (*b*) Sub-Committee on information on water resources (*chairman*, Prof. J. Proudman). "(i) To review the current activities which contribute to our knowledge of the nation's water resources; (ii) to define the additional work needed to make a balanced survey of the quantity and quality of surface and underground water available for domestic, industrial and agricultural use; (iii) to advise on ways of collecting and interpreting the necessary information, correlating it with information from other sources and publishing it".

Society for Visiting Scientists: Report for 1954–55

The annual report of the Council of the Society for Visiting Scientists, presented to the eighth general meeting on September 27, welcomes an additional grant of £1,500 from the British Council, which has enabled the Society to undertake necessary repairs and improvements to its house at 5 Old Burlington Street, London, W.1. Prof. W. Wardlaw has succeeded Prof. F. J. M. Stratton as joint honorary secretary. Though a small increase has been made in the charges, the facilities offered to scientists staying at the Society's house have been considerably improved. The information service has also been extended, as well as the use made of it, and has proved useful in Britain as well as overseas for locating individual scientists or obtaining particulars of their special fields. It has been necessary, for financial reasons, to reduce to a minimum the receptions given to special groups of scientists or to distinguished individual scientists from abroad, and it has also been decided to concentrate on a limited number of discussion meetings in each session. Those held during the past session dealt with nuclear energy in industry and medicine; recent research on speech; colour from the point of view of the painter and the scientist; and current concepts of allergy. The home British membership of the Society has increased to three hundred and twenty (including sixty temporarily abroad), and the total membership exceeds two thousand five hundred. Personal contact still seems to be the most effective form of publicity for the Society.

Publicizing the Chemical Profession

Under the title "Public Relations for the Chemical Profession", the American Chemical Society News Service has issued a handsome brochure, replacing

the booklet "Publicizing the Chemical Profession" and the volume "The American Chemical Society News Service—Voice of the Chemical Profession", issued in 1951. The objectives of this News Service are stated to be: to increase public understanding of the meaning and importance of chemical progress; to encourage sound development of chemical science and industry, thereby promoting the welfare and security of the nation; to improve the professional, economic and community status of the chemist and chemical engineer; to enhance the public recognition and prestige of the American Chemical Society, its divisions, local sections and individual members; and to acquaint well-qualified young men and women with the nature of opportunities for careers in the chemical profession. The News Service makes full use of the press, radio, television and other media in disseminating information about the chemical profession and also co-operates closely with other organizations. The account of its activities, and perhaps particularly the use being made of broadcasting and television, should be of considerable interest to British readers concerned with the promotion of the public understanding of science. Both in the brief historical review of the development of the News Service and in the account of the work done in this field by local sections of the American Chemical Society and other agencies of the Society, the brochure contains material which is relevant and suggestive in the context of the dissemination in Britain of accurate information on scientific and technical matters generally; and the concluding remarks about the responsibilities of the individual member of the American Chemical Society apply almost equally to the scientist in general, in Britain as well as in the United States.

Inland Fisheries Training Centre in Java

An international centre for advanced training of government officers in the development of inland fisheries and fish culture, organized by the United Nations Food and Agriculture Organization in co-operation with the Government of Indonesia and the Indo-Pacific Fisheries Council, has been opened in Java, and the first course, lasting until December 10, has been started, the participants coming from Australia, Burma, Ceylon, Hong Kong, India, Indonesia, North Borneo, Pakistan, Philippines, Sarawak and Thailand. Instruction is given at the Centre in the basic principles of limnology, the operation of small, controlled bodies of water maintained simply for fish production, and the wider field of improving fish production in natural fresh- and brackish-water areas. Methods of management such as the addition of nutrients to the waters, the control of predators and water weeds and the introduction of new species of fish are reviewed. The participants will spend about half their time attending lectures and working at the laboratory and experimental ponds of the Indonesian Inland Fisheries Service at Bogor, and the remainder of their time will be devoted to field trips throughout Java. The Food and Agriculture Organization is applying considerable efforts to the development of fish farming, and has engaged, as a short-term consultant, a senior farm-management specialist of the United States Department of Agriculture, who is at present studying the economics of fish culture in West Germany, Israel, India, Thailand and Malaya. He will lecture on his conclusions at the centre in Java. The staff for the centre has been recruited from Belgium, China, France, Holland, India, Indonesia and the United States. Indonesia has been chosen by the Organization because of the importance of inland fisheries as one of the country's primary industries. There are large areas of inland water, both fresh and brackish, swiftly flowing and still. Many of the varieties of fish are indigenous; but a number have been introduced from abroad, including most notably carp and tilapia. There is a well-developed inland fishery administration and a highly organized and competent fishery research and extension service.

Geology of Rockall

At a meeting of the Geological Society of London at Burlington House on November 2, Dr. P. A. Sabine exhibited, on behalf of the Geological Survey and Museum, rock specimens collected on Rockall by Mr. James Fisher during the recent visit there by the Royal Navy. Dr. Sabine directed attention to the small size of the island, the visible portion of which, he pointed out, would fit inside the Geological Museum. A portion of a specimen collected in 1862, on one of the three previous landings, was also exhibited, as well as air photographs. The new specimens of rockallite, an ægirine granite, already known to be unusually rich in zirconium and cerium, are being examined by officers of the Geological Survey. Mr. James Fisher, who was present at the meeting, then gave a graphic account of the landing. The Rockall specimens are now on view to the public in the Geological Museum.

Photoelectric Measurements at Kvistaberg Observatory, Sweden

A description of the photoelectric instrument at the Kvistaberg Observatory is given in an article by Åke Wallenquist (*Kungl. Svenska Vetenskapsakademiens Handlingar*, Fjärde Serien, Band 5, Nr. 5; 1954), in which all the parts are very carefully explained with the aid of a number of diagrams and photographs. Kvistaberg Observatory, which forms part of the University of Upsala Observatory, is situated at Bro, Uppland, on the slope of a hill on the northern shore of an arm of Lake Mälaren, long. 17° 36·4′ E., lat. 59° 30·1′ N. The photoelectric instrument is a 41-cm. Cassegrain telescope, the primary parabolic mirror of which is of 'Pyrex' glass and was refigured at Upsala after it had arrived from the United States. The mounting of the instrument is of the German equatorial type, and the axes, which originally belonged to an old 9-in. refractor at Upsala Observatory, are made of steel and are heavy; the system of axes was modernized in the Observatory workshop and furnished with ball-bearings. Owing to rather unfavourable weather conditions at Kvistaberg for photoelectric photometry—like many other places in Sweden—differential observational programmes are generally undertaken with the object of eliminating the effects of sudden variations in the transparency of the atmosphere. For this reason, photoelectric determinations of the colours of the stars and determinations of differences in the magnitudes of the components of double stars form the main programme at the Observatory, though under good seeing conditions it is possible to carry out more absolute photometric photometry, with the determination of magnitudes of individual stars. Two colour-filters are used for the determinations of colours and magnitudes of the stars—a blue filter of type *BG* 12 and a yellow filter of type *GG* 11, supplied by Schott und Gen., Jena. The article contains

a table with the final values of the m_{pg} magnitudes and colours of fourteen north polar sequence stars as measured photoelectrically at Kvistaberg.

Copals and their Botanical Origin

THE study of fresh copals of known botanical origin has shown that, with some exceptions, their discrimination by the usual characteristics is imprecise and hazardous. On the other hand, it has now been shown that the infra-red spectrographs of their extracts are characteristic and specific (L. Hellinck, *Publ. de l'Inst. Nat. pour l'Étude Agron. Congo Belge* (I.N.É.A.C.); Sér. Tech. No. 44, 1955). When the spectrographic method was applied to the study of 'fossil' copals, it was concluded that these had been produced by the same species that yield fresh copal, *Guibourtia demeusei* and *Tessmannia anomala* being the most important two in that order. It has also been confirmed that, in the course of a few months, freshly exuded copals possess the collective properties of 'fossil' copal. Hence it has not been possible to study the ageing of copal or to assign precise ages to fossil materials.

Colonial Service: Recent Appointments

THE following appointments have recently been made in the Colonial Service: R. F. Cumpston and R. B. Royle (agricultural supervisors, Nyasaland), principal agricultural supervisors, Nyasaland; C. E. Moore (agricultural officer, Gold Coast), senior soil conservation officer, Gold Coast); J. D. Tallantire (senior agricultural officer, Federation of Nigeria), principal agricultural officer, Federation of Nigeria; I. T. Twyford (soil scientist, Fiji), chemist, Department of Agriculture, Fiji; D. H. Welch (principal agricultural officer, Western Region, Nigeria), deputy director of agriculture, Western Region, Nigeria; W. M. C. Bagshaw (assistant conservator of forests, British Guiana), deputy conservator of forests, British Guiana; J. D. Scott (specialist forest engineer, Nigeria), conservator of forests, Sierra Leone; J. L. J. Vinson (curator, Mauritius Institute), director, Mauritius Institute; A. C. Evans, assistant director (research), Tanganyika; S. Gray, senior agronomist, Uganda; C. Harkness, plant breeder (botanist), Northern Region, Nigeria; F. M. Spencer and J. V. Webdale, agricultural officers, Tanganyika; D. P. Taylor, agricultural officer, Kenya; D. D. Thornton, pasture agronomist, Uganda; P. A. Board, fisheries officer, Eastern Region, Nigeria; M. H. D. Dowell, assistant conservator of forests, Nyasaland; P. J. Fogg, assistant conservator of forests, British Honduras; P. A. Skott, assistant conservator of forests, Tanganyika; P. E. Brown and R. Halligan, geologists, Tanganyika; R. T. Gittins, field officer (geology), Uganda; B. Hitchon, geologist, Northern Rhodesia; G. Surtees, research entomologist, West African Council for Medical Research, Nigeria; J. Lamb, director, West African Cacao Research Institute, Gold Coast; K. C. Sleep, scientific officer (chemist), Tanganyika; K. Horlyck, veterinary officer, Northern Region, Nigeria.

Announcements

THE Royal Swedish Academy of Technical Sciences (IVA) has conferred its highest mark of distinction, the IVA Grand Gold Medal, on Dr. K. H. Gustavson, of the Swedish Tanning Research Institute, Stockholm, in recognition of his pioneering contributions to the chemistry and reactivity of collagen, and for his investigations of the mechanism of tannage, particularly his research on the reaction of chromium compounds with hide protein in chrome tanning. Dr. Gustavson is president of the International Union of Leather Chemists' Societies.

SIR RAYMOND PRIESTLEY has temporarily been appointed director of the Falkland Islands Dependencies Scientific Bureau during the absence of the permanent director, Dr. V. E. Fuchs, who is to lead the forthcoming trans-Antarctic Expedition.

DR. R. K. SCHOFIELD, head of the Chemistry Department, Rothamsted Experimental Station (*Nature*, 175, 283; 1955), has been appointed reader in soil science in the Department of Agriculture, University of Oxford, in succession to Dr. E. Walter Russell, who is now director of the East African Agriculture and Forestry Research Organization (*Nature*, 175, 1065; 1955).

DR. D. E. TRIBE, lecturer in animal husbandry in the University of Bristol, has been appointed to a readership in the physiology of domestic animals in the University of Melbourne.

THE University of Sheffield has appointed Dr. T. R. Kaiser and R. C. Curran to be senior lecturers in physics and pathology, respectively. The following have been appointed lecturers: Dr. R. C. Cass (chemistry), Dr. T. P. H. McKellar (psychology), Dr. V. A. Phillips (metallurgy) and Dr. A. N. Stroh (physics).

DR. K. P. BISWAS, formerly superintendent of the Indian Botanic Garden (*Nature*, 176, 239; August 6, 1955) has been appointed, as from August 1, director-in-charge of Medicinal Plants Schemes in India to develop the vegetable wealth of the country. The work is being done under the auspices of the Medicinal Plants Committee of the Indian Council of Agricultural Research, Government of India, and Medicinal Plants Committee of the Government of West Bengal, of which Dr. B. C. Roy is chairman and Dr. Biswas secretary.

THE Industrial Section of the Royal Microscopical Society is arranging a symposium and exhibition on "Fibre Microscopy", to be held at the Royal Pharmaceutical Society, 17 Bloomsbury Square, London, W.C.1, on November 16 (2–9.30 p.m.). The exhibition will consist of fourteen displays from government laboratories, research associations and private firms. Further information can be obtained from the Assistant Secretary, Royal Microscopical Society, Tavistock House South, Tavistock Square, London, W.C.1.

THE National Coal Board has decided to change the titles of its Central Research Establishments: the Central Research Establishment I, at Stoke Orchard, near Cheltenham, will now be known as the Coal Research Establishment, and Central Research Establishment II, at Isleworth, as the Mining Research Establishment. The changes have been made to indicate the character of the work carried out at the two Establishments.

REFERRING to their advertisement in *Nature* of October 15, supp. p. iii, of "The Geneva Series on the Peaceful Uses of Atomic Energy", Messrs. Macmillan ask us to point out that each volume of the series will probably be priced at 55*s*. and that the subscription terms inadvertently included in the advertisement will not apply.

IMPORTANCE OF LARVAL CHARACTERS IN CLASSIFICATION

A MEETING of Section D (Zoology) of the British Association was held at Bristol on September 5, with Prof. F. W. R. Brambell in the chair, to consider the importance of larval characters in classification. Dr. F. I. van Emden, who opened the discussion, said that in wingless insects such as the silverfish adult and larva are much alike. In winged insects this is not so, and it is clear that adult and larva must have evolved along quite different lines. It follows that neither adult nor larval characters have over-riding importance for taxonomy: theoretically they are of equal importance. Where a resting pupal stage intervenes, many characters are quite unrelated in adult and larva. Where such a stage is absent, larva and adult have often evolved in such different environments that their classification has to be based on entirely different criteria. In practice, either stage may chance to exhibit better taxonomic characters.

In most insect groups our knowledge of the larvæ is still exiguous, but a fair number of cases are already known in which the larvæ are easier to distinguish than the adults, for example, among sphingid moths, mosquitoes, *Culicoides* midges, meloid beetles; and further examples doubtless await discovery. As a rule, however, the adults show a greater degree of differentiation than the larvæ, and consequently their characters are likely to remain more important for species determination. Larval characters, on the other hand, are likely to retain greater importance for classification than for identification. Thus the major divisions of winged insects are named with reference to larval development (Exoptergota, Holometabola, etc.). Larval characters are used extensively in the classification of Diptera, Hymenoptera, Coleoptera and Aphioidea, and they are almost as important as those of the adult for subdividing Odonata and Neuroptera. Examples of changes that have been made mainly, or entirely, with reference to larval characters are: inclusion of the order Strepsiptera in the Coleoptera; removal of the Aphaniptera (fleas) from the Aptergota to a position among winged orders near the Diptera, a step first advocated by Lamarck in 1801. Since classification attempts, at least to some extent, to summarize phylogeny, it follows that larval characters have a similar part to play in phylogenetic studies. Thus acceptance of Chapman's order Zeugloptera implies agreement with the assumption that this group must have separated from the Lepidoptera sooner than did the Trichoptera. Revision of the systematic position of the Archostemata implies a revision of our ideas concerning the evolution of the coleopterous larva. At a lower level, larval characters afford clear evidence regarding the evolution of stridulating organs, armature of the teeth ventrite and other structures.

Finally, larval identification is important not only for taxonomy *per se* but also for all those branches of biology which taxonomy subserves. For example, the results of quantitative ecological research would be incomplete if larval forms had to be neglected because they could not be identified.

Dr. Isabella Gordon then discussed the systematic position of the Euphausiacea, a small but economically important group of Crustacea Malacostraca once placed with the Mysidacea in the old order 'Schizopoda'. The best-known member of the single family Euphausiidae is undoubtedly *Euphausia superba*, the krill or whalefeed. Larval development and adult structure indicate close affinity with the lower Decapoda, especially the Penaeidea, and for the past fifty years Euphausiacea has been considered an independent order of the division Eucarida co-ordinate with Decapoda. Some twenty years ago the late Dr. Stanley Kemp, then director of the *Discovery* Investigations, was convinced that Euphausiacea are true Decapoda related to the Sergestidae. Unfortunately his views, though fully endorsed by Calman, were never published, and Gurney (1942) was the first definitely to place Euphausiacea in the Decapoda. His suggested classification is little, if any, improvement on the old one; but his comparison of Euphausid development with that of the Penaeidea is excellent.

Most Eucarida incubate their eggs, which are attached to the abdominal pleopods; but neither Euphausiacea nor Penaeidea do this—their eggs are either shed freely or adhere for a brief period to the posterior thoracic appendages. Moreover, Euphausiacea and Penaeidea are the only Malacostraca with free nauplius larvæ. Penaeidea would appear to be more primitive than Euphausiacea; for example, there is no compression of the thoracic somites such as occurs in all other Eucarida, and the Penaeidae have elongated pear-shaped nauplii. In Euphausiacea there is extreme compression of the thorax and the appearance of the second and subsequent thoracic appendages is long delayed, except in *Euphausia superba*, which acquires precociously the swimming and feeding habits of the adult. Euphausid development, though gradual as in many Penaeidae, is remarkably close to that of the Sergestidae, where there is abrupt metamorphosis at the end of each phase. In Sergestidae also, there is the same tendency to reduction or loss of the last two pairs of thoracic appendages (post-larva, *Lucifer*) and, in some species at least, to enlargement and modification of one pair of maxillipeds. Then there is general similarity of such adult structures as the male copulatory petasma and spermatophores, the female sperm receptacle (thelycum) and the photophores. The resemblances far outweigh the differences, chief of which is that in Euphausids the gills, which are specialized podobranchs, are exposed, not concealed by the carapace—but *Lucifer* has no gills at any stage.

Calman, in a letter dated May 27, 1948, suggested making the Euphausiidea co-ordinate with Penaeidea, Caridea, etc.; Gurney was in favour of uniting the two groups with free nauplius-protozoea development in one suborder as against the rest of the Decapoda (letter dated February 12, 1949). At present the writer is undecided as to the best course to adopt. The classification of the Decapoda is a very difficult problem, and none of the schemes hitherto proposed is entirely satisfactory. (See also p. 934 of this issue of *Nature*.)

A review of recent work on larval characters in helminths by Dr. Sheila M. Willmott followed. Many helminths are highly pathogenic parasites of man and animals and, in the case of some nematodes, also of plants. All have complex life-histories including several larval stages. In the three main groups of

helminths—the nematodes, trematodes and cestodes—the larvæ may show a combination of adult and larval characters. For example, in cestode larvæ the head is identical with that of the adult, but the form of the cyst is a purely larval character; in the nematodes, the gut of the larva may take the form that it shows in the adult. In the digenetic trematodes, the body of the cercaria shows such adult characters as the arrangement of the head and collar spines in the echinostomes, the absence of an œsophagus in the schistosomes and the position of the ventral sucker in the amphistomes; the tail is purely larval, although its form is frequently characteristic of the group to which the adult belongs. The character now most used in the classification of the cercariæ is the basic formula of the excretory system. This frequently resembles the arrangement found in the adult, and the fundamental flame-cell pattern forms a basis for a 'natural' classification.

Hydatid disease, which is widespread throughout the world and is more common in Great Britain than is generally realized, is caused by a larval cestode. Whether one species is responsible for the two types of hydatid disease or whether two species are involved has long been a matter of controversy. Careful investigation of the types of larvæ and the life-cycle have now led to the conclusion that two species of *Echinococcus* are involved.

Recently much work has been done on larval nematodes, particularly the Spiruroidea, with the result that a scheme of classification proposed twenty years ago and based on the morphology of the head has been confirmed. As many nematodes are free-living, it is concluded that the parasitic mode of life has been more recently acquired in this group than in the trematodes and cestodes. The degrees of adaptation of nematode larvæ to the intermediate hosts are probably better indications of phylogenetic relationships than are the relations of the adult to the definitive hosts. Four main types of larvæ are recognized: (1) the most primitive, that is, free-living larvæ; (2) larvæ developing to the third stage before hatching; (3) larvæ which develop in a vertebrate intermediate host but which act as ecto-parasites rather than as endoparasites; and (4) the most specialized, that is, those which develop in a vertebrate intermediary with a strongly marked degree of 'séclusion' within it, or which have secondarily lost the intermediate host.

The last paper was entitled "The Classification of Nematodes parasitizing Horses, using Larval Characters". Mr. D. Poynter said that to-day the horse commonly harbours large numbers of various species of nematodes, and these are often the cause of retardation in growth, illness and sometimes death. The effects of parasitism have undoubtedly been aggravated by domestication. The typical horse nematode lives as an adult in the intestines of its host and lays eggs which are passed out, with the fæces, on to the pasture. The eggs hatch and give rise to third-stage infective larvæ which live on the herbage and are ingested by the host. Equine nematode parasites all belong to the superfamily Strongyloidea; but the eggs of the various genera and species are indistinguishable from each other. Since the adults are inaccessible within the host, it is essential to obtain the free-living larval stages, and this is done by means of a special culture technique. After seven days at 28° C. in a fæces–charcoal culture, development has proceeded as far as the third-stage larvæ, which have definite diagnostic characters. These larvæ have been described for some of the genera and species, and a key published in 1948 facilitates the determination of the larvæ obtained from equine fæces. Unfortunately, this key is not illustrated. But a plate has now been prepared showing the various larvæ drawn to the same scale. It is possible, therefore, by identifying the larvæ in a given culture, to obtain knowledge of the types of nematodes in the host. A survey has been undertaken using many horses, and information has been obtained as to the incidence of the different nematodes in hosts of different ages.

This culture procedure has also an important practical application. Parasites of the family Strongylidae are all affected to some extent by phenothiazine, a common anthelmintic which has no effect on *Trichostrongylus axei*. For this parasite, copper sulphate and nicotine must be used. Any rational treatment, therefore, must include a prior determination of the larvæ. A careful comparison of larval cultures obtained before and after dosing will indicate the effectiveness of a new anthelmintic against the different nematode species. For example, when testing the efficiency of piperazine adipate, it was noted that every adult horse dosed showed an immediate and sharp rise in the number of eggs of *Strongylus edentatus* being passed. Subsequent critical tests proved the compound to be only 0·6 per cent effective against this species.

The general discussion which followed not unnaturally centred around the insects. Prof. G. C. Varley emphasized the practical importance to the ecologist of correlating observations on the behaviour of the adults with their life-histories, giving examples from his work on parasitic Hymenoptera. Mr. P. F. Mattingly referred to recent immunological work on mosquito taxonomy, the discovery in mosquitoes of some of the evolutionary anomalies discussed by de Beer in his book "Embryos and Ancestors", and Wigglesworth's recent brilliant exposition of the concept of insect metamorphosis as a special case of the more general phenomenon of polymorphism. He also stressed the need for comparative genetical studies on the inheritance of adult and larval characters.

ISABELLA GORDON

INSTITUTE OF PHYSICS

REPORT FOR 1954

THE thirty-fifth annual report of the Board of the Institute of Physics*, covering the work of the Institute during 1954, was presented to the annual general meeting of the Institute, held at the Institute's house in London on May 17. The report records that the membership in the several grades of the Institute continues to mount steadily, and the total membership has increased by 154 to 4,749. The newly established examination for entry to the graduateship grade of membership of the Institute was held during June 21–25 at centres in London, Birmingham and Paisley, and nineteen of the fifty-four candidates were successful. The numbers of candidates for the final examinations for National Certificates in Applied Physics were 206 for the Ordinary level and 75 for the Higher Certificate,

* Thirty-fifth Annual Report of the Board of the Institute of Physics, 1954. Pp. 25. (London: Institute of Physics, 1955.)

compared with 151 and 55, respectively, in 1953. A one-day conference, consisting of representatives of teachers in technical colleges offering courses for National Certificates in Applied Physics, the Institute, the Joint Committee for National Certificates in Applied Physics, and industry, was held on April 12, 1954, and eight papers were read.

About half the total work of the Institute is now occupied by the production and distribution of its publications. The Institute publishes two monthly journals, the *Journal of Scientific Instruments* and the *British Journal of Applied Physics*, and, in addition, a monthly *Bulletin* which is circulated to members only. For the 1954 volume of the *Bulletin*, an entirely new format was introduced, its contents consisting of twenty articles, either invited contributions or based on lectures given to the Education Group of the Institute, and Institute news. A new edition of the pamphlet entitled "The Scientific Education of Physicists", giving up-to-date information regarding institutions where physics may be studied, and a revised edition of the thirty-two page pamphlet, "Notes on the Preparation of Contributions to the Institute's Journals and Other Publications", were issued during the year. A third selection of "Laboratory and Workshop Notes" from the *Journal of Scientific Instruments* was compiled and edited by Dr. Ruth Lang and published in book form.

The report states that the Institute has continued to take an active part in discussions on higher technological education, but has not departed from its original view expressed in its 1948 report on this subject. For the second year in succession an inquiry was addressed to all new graduates in physics of the universities in Great Britain to obtain information as to their present occupations, or, where appropriate, the source of any maintenance grant. The survey is to be continued during the next few years so as to determine how, and to what extent, the services of physics graduates are being utilized. Reports were received during the year that there were several vacancies for undergraduates in physics departments in some universities and large technical colleges, and the Board's inquiries on this subject are to be issued shortly.

Details of the activities of the sixteen local branches and specialist subject groups of the Institute are listed in the report. The Australian Branch, with 415 members and four separate divisions in New South Wales, Queensland, South Australia and Victoria, respectively, held thirty-two meetings. Dr. A. C. Menzies and Prof. J. H. Bhabha visited the Victoria Division and delivered addresses, and this Division also held an exhibition of scientific apparatus in March and a conference on the teaching of physics in August. Joint meetings were held by the Electronics Group of the Institute with the Manchester and District Branch in Manchester and with the South Wales Branch in Swansea, and two conferences were also organized: the first, on luminescence, was held in April at the Cavendish Laboratory, Cambridge, and the second, on fluctuations and the limits of measurement, in September at the Institute's house in London. The proceedings of the former conference have since been published (*Brit. J. App. Phys.*, **6**, Supp. 4; 1955). Following discussions with the Physical Society, a joint committee for electron physics was set up to co-ordinate activities of the two bodies in the field of electron physics, defined as "the physics of the free electron and phenomena associated with it". The Electron Microscopy Group was host to an international conference of the recently established Joint Commission on Electron Microscopy, which was held during July 16–21 in London and attended by about four hundred people; the X-ray Analysis Group held its spring conference in Cambridge on the subject of "New Developments in Structure Analysis" and its autumn conference in London on "Structure of Metals". Also, in addition to the specialist conferences held by its branches and groups, the Institute held a conference on "The Physics of Particle Size Analysis" in the University of Nottingham during April 6–9. Thirty-three papers were presented and discussed, and the proceedings have been published (*Brit. J. App. Phys.*, **5**, Supp. 3; 1954).

At the general meeting of the Institute, the following were elected to take office on October 1: *President*, Sir John Cockcroft; *Vice-President*, Dr. W. H. Taylor; *Honorary Treasurer*, Dr. S. Whitehead; *Honorary Secretary*, Dr. B. P. Dudding; *New Ordinary Members of the Board*, Dr. M. R. Hopkins, Dr. J. M. A. Lenihan and Dr. J. Taylor. In addition, Prof. W. E. Curtis and Dr. C. Sykes (*past-presidents*), Mr. O. W. Humphreys, Mr. G. R. Noakes and Prof. F. A. Vick (*vice-presidents*), and Dr. H. Barrell, Dr. P. H. S. Henry, Dr. K. A. G. Mendelssohn, Mr. A. T. Pickles and Mr. H. P. Rooksby continue to serve on the Board.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON

IN his inaugural address for the new session of the Imperial College of Science and Technology, London, the rector, Dr. R. P. Linstead, after reviewing briefly the history of the College, referred in some detail to certain aspects of the expansion which is planned to bring the total number of students to three thousand by 1962 without sacrifice in quality. The College is already, Dr. Linstead stated, the largest postgraduate college in Great Britain, providing in technology about one in nine of those trained in the country, while the proportion of higher degrees to total degrees is nearly 40 per cent. New senior posts at the level of professor or reader have already been or are being established in soil mechanics, statistics, instrument technology, applied geophysics, aeronautical structures, applied science, biochemistry, inorganic chemistry, light electrical engineering, parasitology, physical metallurgy, applied geochemistry, nuclear power and other subjects; but it is not intended to multiply new departments. The latest demands all call for sound fundamental training in mathematics and in the basic sciences or the main divisions of engineering, and to meet this demand the academic staff has already been increased by more than a third. At the same time, the College is providing, from its old students and staff, men and women for senior academic appointments elsewhere.

Dr. Linstead anticipates no difficulty in finding sufficient undergraduate students: he thinks that the danger of a breakdown in school science teaching had been exaggerated and is being removed, and that the post-war bulge in the school population will of itself more than meet the 17 per cent increase in annual intake of undergraduates required to maintain a total of three thousand students (including about sixteen hundred undergraduates). The College

is concerned, however, to improve selection and to make the best possible use of the students who have been selected, so as to reduce the present wastage; about a hundred of the present intake of five hundred freshmen fail to go forward to the second year. In this connexion, Dr. Linstead said the College hopes soon to reintroduce an optional preliminary year which would not demand a knowledge of science and would thus provide a special means of access for the gifted non-scientist. This scheme is related to one invented by Sir Henry Tizard during his rectorship, but the majority of the first-year entry would continue to have had a sound science training at school.

Last year there were 631 full-time postgraduate students, or rather more than a third of the total, and it is intended to raise this proportion to 45 per cent. Most of the postgraduate students are taking advanced courses designed to train technologists of the highest quality. Postgraduate research is a first charge on the College, and Dr. Linstead stressed the proportion of postgraduates from overseas—at present about three hundred from forty-nine centres, mainly in the Commonwealth. Nearly two hundred of the postgraduate students came from posts in industry and in government, and in this connexion Dr. Linstead is less confident about maintaining the supply of postgraduate students, unless maintenance support is forthcoming on an adequate scale.

The College aims to produce engineers and scientists who are at the same time well-educated men and women, and Dr. Linstead thinks that this is being achieved. As regards residence, however, the College is in the worst position of all major colleges or universities in Great Britain, only 8 per cent of its students during 1953–54 being residential. It is proposed to increase this to 16 per cent, or about five hundred students, by the end of the expansion period and also to provide general amenities for all its students on the lines of what is commonly called the Ashby plan. In his address, Dr. Linstead made no specific statement on the building plans, but expressed the opinion that the decisions taken in 1953 were wise and also paid tribute to the co-operation of all concerned, not least of the 1851 Commissioners.

ONTARIO RESEARCH FOUNDATION

REPORT FOR 1954

In his annual report for 1954 to the chairman and governors of the Ontario Research Foundation*, the director of research, Dr. H. B. Speakman, notes that, in spite of a recession in some branches of industry, there was no marked reduction in the demands made on the Foundation but rather an increase in developmental work. The Biochemistry Department was very active, work under the Rice Mills Fellowship centring largely on the development of a new milling principle designed to reduce drastically the amount of broken rice that is normal with present equipment. In the utilization of municipal waste, progress has been made in partial conversion into sugars such as xylose and certain volatile organic acids. In a fundamental study of the continuous production of protein by fermentation of yeast, it has been established that there is practically no waste of sugar and that a higher percentage yield of yeast on the sugar consumed is obtained by feeding sugar at low rather than at higher concentrations. The basic study of the deterioration in flavour of edible oils continued, and substantial progress was made in the group fellowship working on the evaluation of new tanning materials.

In the Department of Chemistry, the balance between basic research, long-term sponsored fellowship projects and short-term investigations submitted by smaller industrial units is emphasized. Filter-paper chromatographic techniques have demonstrated that normal sodium phosphate glasses, rapidly quenched from the molten state and dissolved in water, show only linear polymers with a reproducible distribution of molecular weight, depending only on the sodium/phosphorus ratio, and the technique has been improved so that small amounts of ring or linear polymers can be determined in the presence of large amounts of the other kind. Two surveys of air pollution, at Maitland and Millhaven, were concluded, and the laboratory is developing new apparatus and methods for the accurate determination of air contaminants. A study of the production of grafted polymers continued, and one of methods for the production of alkyd resins has indicated that straight-chain alkane sulphonic acids may be suitable catalysts in the condensation. Definite progress is reported in the study of the chemistry of waste sulphite liquors; a number of lignin compounds have been examined as dispersing agents for use in drilling oil-wells, while others may be useful in treating boiler feed water to prevent scaling, and a condensate of lignin and phenolic compounds was found to possess tanning properties.

In the Department of Engineering and Metallurgy, investigations on the production and properties of steel of controlled density have led to striking improvements in the product, and the study of the causes and the detection of faults in wire ropes has led to some progress in the design of an instrument which can be used at the mines under operating conditions.

The Department of Parasitology continued its work on tapeworms found in carnivorous animals as well as a survey of animals infected with the larval or adult forms of the parasites. Work on flies of the genus *Protocalliphora* continued, as well as the investigation of the filariid nematodes in birds; and the extensive researches on two species of flukes of the genus *Alaria*, occurring in foxes, are almost complete. Further data on the epizootiology, transmission and development of *Leucocytozoon* in ducks confirmed the conclusion that asexual parasites occur in the blood of infected ducks during their cycle of development.

The Department of Physiography finished the mapping between North Bay and Sault Ste. Marie and made differential thermal and X-ray analyses on the clay, less than 1 micron in diameter, from all main types of glacial till in southern Ontario. A new installation for evapo-transpiration studies was set up at Kapuskasing Experimental Station, and an unbroken daily record was secured for the summer months; a study of soybean growth and development was commenced on five varieties with a range of maturity.

In the Textiles Department, besides research on nylon, the optimum temperature at which fabrics from different synthetic fibres can be ironed has been studied, as well as factors affecting the photochemical degradation of viscose rayon.

* Ontario Research Foundation. Annual Report, 1954. Pp. 30+4 plates. (Toronto: Ontario Research Foundation, 1955.)

THE STRUCTURE OF COLLAGEN

By Dr. ALEXANDER RICH* and Dr. F. H. C. CRICK

Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems, Cavendish Laboratory, Cambridge

VERY recently, Ramachandran and Kartha[1] have made an important contribution by proposing a coiled-coil structure for collagen. We believe this idea to be basically correct but the actual structure suggested by them to be wrong.

Their structure consists of three polypeptide chains, each having approximately a three-fold screw axis. In addition, the chains slowly wind around each other to form a coiled coil, thus reproducing the observed non-integer screw axis[2]. The major helix is right-handed, the minor one left-handed. Each chain is held to its neighbours by *two* sets of systematic hydrogen bonds.

The allowed sequence of residues is

—*G*—*R*—*P*—*G*—*R*—*P*—, etc.,

where *G* implies glycine only, *R* implies any residue except proline or hydroxyproline, and *P* implies any residue, but usually proline or hydroxyproline.

We believe this structure to be wrong for two reasons. (1) It is stereochemically unsatisfactory. In particular, there is a very short C_α—C_α contact of 3·3 A. (normally 3·6–4·0 A.) and an extremely short C_α—O contact of 2·6 A. (normally 3·2–3·5 A.). In addition, the hydrogen bond angles are on the outside limit of the values usually found. (2) It is not compatible with recent work[3] on the amino-acid sequence, which shows that

—gly—pro—hypro—

is a common sequence in collagen.

On the other hand, Dr. Pauline Cowan and her co-workers[4] have informed us that a preliminary optical diffraction pattern of this structure agrees qualitatively with the observed wide-angle X-ray pattern of collagen. They have also pointed out to us that the configuration of the backbone of the polypeptide chain is similar to that found by them for polyproline[5]. These facts suggest that the structure, though incorrect, is on the right general lines.

Our own work on collagen has sprung from our recent structure for polyglycine II[6]. We have taken a compact group of three adjacent chains out of the polyglycine lattice (space group $P\,3_1$) and twisted them, as in the Ramachandran–Kartha structure, to form a similar coiled coil. Such a group can be selected in two different ways, since the symmetry is trigonal, not hexagonal. We have called the two resulting arrangements structure I and structure II. Both have a right-handed major helix and a left-handed minor helix, arranged to fit the observed non-integer screw. Both have only one set of systematic hydrogen bonds linking neighbouring chains. In structure I the NH-groups point anticlockwise when viewed from the carboxyl ends of the chains; in structure II clockwise.

These two structures are thus similar to that of Ramachandran and Kartha in being three-chain coiled-coil structures; but they differ in having only one set of systematic hydrogen bonds instead of two. Moreover, they are both stereochemically completely satisfactory.

Both structure I and structure II will accommodate the sequence

—gly—pro—hypro—

but they do so in a different manner. In structure II the glycine position is near the axis, and every third residue must be glycine. The proline and hydroxyproline positions, on the other hand, are far removed from the axis. Either proline or hydroxyproline can go into either position—there seems to be no preference—and in neither case can the OH of hydroxyproline make a hydrogen bond with a CO group of an adjacent chain within the same set of three chains.

Structure I will also accommodate the above sequence; but when the hydroxyproline is in the expected position (that is, previous to glycine) its OH group can form a hydrogen bond to one of the adjacent chains within the same set. Careful structure building has shown that not all the possible positions for hydroxyproline can be occupied if the structure is to fit together comfortably. This is compatible with the amino-acid analyses of collagen, which show that the amount of hydroxyproline present in bovine collagen[7] would fill about one-third of these sites. The polypeptide backbones, being held together by only one set of hydrogen bonds, have a certain amount of flexibility. In the undeformed structure, only glycine can be accommodated in the glycine sites. However, if the structure is deformed somewhat, these sites can accommodate other residues, though only to a limited extent. This may explain certain minor features of the amino-acid sequence data.

We have made an exhaustive study of all possible structures (using topological enumeration, similar to that of Bragg, Kendrew and Perutz[8]) of this general type which are compatible with the observed screw axis—that is, with three parallel chains linked by at least one systematic set of hydrogen bonds—and we find that: (1) no structure with *two* systematic sets of hydrogen bonds is stereochemically possible; (2) no other structure with *one* systematic set of hydrogen bonds is stereochemically satisfactory except the two described above derived from polyglycine. Neither were we able to add occasional backbone hydrogen bonds to structures I and II in a convincing manner.

All the above findings are independent of arguments about the side-chain arrangements. We therefore conclude that structures I and II, though making few hydrogen bonds systematically, are the best that can be achieved along these lines. Note that, as in polyglycine II[6], it is not impossible that the direction of one of the three chains may be reversed.

Preliminary work on the optical transforms of these two structures (carried out with Dr. A. Elliott on his optical transform machine) show both structures to give rough agreement with the X-ray pattern, though structure II shows a discrepancy on the fourth layer-line. Both structures are also compatible with the infra-red[9] observations. Further work will therefore be required to decide between them. We are at the moment inclined to favour

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structure I, because it makes effective and systematic use of the hydroxyproline residues. Gustavson[10] has presented extensive evidence suggesting that this unusual amino-acid stabilizes the collagen structure. We feel that this is more likely to take place by formation of hydrogen bonds within a group of three chains than between different groups of chains[1]. In addition, structure I explains in a natural way the amino-acid sequence data. Thus while the peptide hypro—gly is common, gly—hypro is not found. Similarly, gly—pro is common, whereas pro—gly is rare. In structure I this preference is explained in terms of the hydroxyproline-hydrogen bond between the chains. Although we cannot at the moment make a final decision between the two structures, we think it very probable that one of them is correct (or, less likely, both). The general agreement with the X-ray pattern, the close resemblance to polyproline and to polyglycine II, and the ability to explain the major features of the amino-acid sequence data all suggest that collagen is a structure of this type; that is, a three-chain, coiled-coil structure, with one set of systematic hydrogen bonds.

Full details of our findings together with co-ordinates of both structures will be presented elsewhere.

We should like to thank Dr. A. Elliott for his assistance in obtaining the optical transforms.

[Oct. 10

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LANGMUIR'S PARADOX

By Dr. D. GABOR, Dr. E. A. ASH and D. DRACOTT
Department of Electrical Engineering, Imperial College of Science and Technology, London

A LITTLE more than thirty years ago, Irving Langmuir and Harold Mott-Smith carried out an important series of investigations on low-pressure mercury discharges[1], on which they based their theory of the positive column in electro-positive gases. They distinguished two regions in the discharge: the almost neutral arc plasma, and the thin boundary sheath which separates it from the tube wall. In the plasma the motion of the ions is regular and mostly radial, whereas the electron motion consists of a regular longitudinal drift, with a superimposed random, Maxwellian component. The random motion corresponds to 'electron temperatures' of the order of several 10,000 deg., many times higher than the gas temperature. The boundary sheath enables the plasma to remain neutral, by maintaining a potential well of such depth that most of the electrons are repelled, and only a small fraction reaches the wall, together with an equal number of positive ions.

This theory was highly successful in all respects except one; but this exception, as Langmuir showed in a number of important papers[2,3], presented one of the worst discrepancies known in science. Once the existence of electron temperatures was accepted, the theory of Langmuir and Mott-Smith could account for all observations, but this phenomenon itself remained not only unexplained but also inexplicable. Maxwellian energy distributions have been observed, in discharge tubes of a few centimetres in diameter, at mercury pressures so low that the mean free path was several times the tube diameter; and, moreover, at such small electron densities that it would take an electron, in the average, a path of the order of 10 m. to exchange amounts of the order of the mean energy with other electrons. The tube wall eliminates all the time electrons above a certain energy limit, and an electron collides, on the average, some thousand times with the boundary sheath before it has a chance to pick up energies of this order. Yet probe measurements fail to reveal any deficit of fast electrons among those returning from the wall, even at a distance of only a few millimetres from it.

Though the existence of electron temperatures has become a well-established part of our knowledge of low-pressure discharges, the fact that this phenomenon persists in a region in which it has theoretically no right to exist appears to have been largely ignored, in spite of Langmuir's emphasis. Our investigations, which started five years ago, have now led to the elucidation of what we propose to call 'Langmuir's paradox'.

The first step was to clear up the question whether the discrepancy between theory and experiment could not be ascribed to faulty theory. Interaction between electric charges in plasmas is very complicated, as the Coulomb forces extend appreciably over spheres containing thousands of other charges; hence there was some reason to distrust the simple theories which considered short-distance interaction between pairs of electrons only. But experiments by two of us (E. A. A. and D. G.[4]) have shown that the scattering and energy exchange of electrons in plasmas and in electron clouds in thermal equilibrium, with densities of the order as they occur in low-pressure discharges, exceed the predictions of the theory based on binary collisions at most by a factor of 2–5. The rather large margin of uncertainty is due to the smallness of the interaction, which makes the measurements very delicate. A theory afterwards developed by one of us (D. G.[5]) indicates that the collective interaction which is neglected in the binary collision theory amounts in fact to a correction of a few per cent only. Thus the mechanism responsible for Langmuir's paradox must arise in some way from the fact that the discharge plasma is not

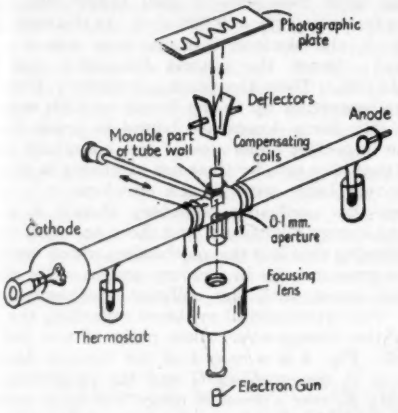

Fig. 1. Apparatus for the measurement and oscillography of plasma-boundary oscillations in a low-pressure mercury arc

in thermal equilibrium, and we started a search for organized oscillations.

Several devices were used in turn in this search, but they mostly had in common the use of electron beam probes for the exploration of the discharge. The principle of the method is illustrated in Fig. 1. A long d.c. mercury arc is maintained in a discharge tube, from which all residual gases are eliminated, while the mercury pressure is maintained by saturation in several carefully temperature-controlled side arms. (The pressures investigated were in the range 0·5–3 microns.) A finely collimated electron beam of 1–20 keV. is shot at right angles through the discharge. It is limited to about 0·1 mm. diameter by an aperture at the entry side, while at the exit side the aperture is made large enough to pass a slightly deflected beam. By pumping vigorously at both sides it was assured that the electrons suffer no collisions except in the discharge space. A section of the wall of the discharge tube, about 2 cm. square, was made movable so that the beam could pass outside or inside the boundary sheath. So long as it passed outside the sheath, that is to say, through the arc plasma, it was found that the beam was neither deflected nor appreciably diffused, which proved the absence of significant oscillatory fields in the plasma.

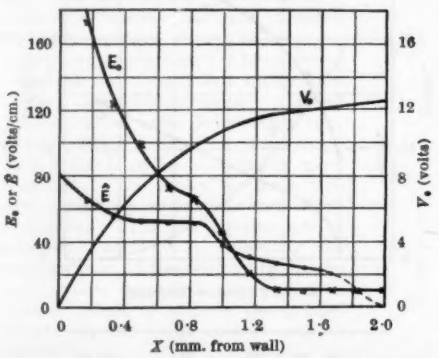

Fig. 2. D.c. field E_0, d.c. potential V_0 and peak value $\hat{E}$ of the oscillating field as a function of the distance x from the wall in the sheath of a mercury arc with the following data: tube diameter 3 cm., mercury saturation temperature 10° C., mercury pressure 0·5μ, $n = 10^9$/cm.^{3}, $T = 26{,}000°$ K.

On the other hand, when the electron probe passed through the boundary sheath, which in these experiments was 1–2 mm. thick, it was deflected and appeared diffused, but only in the direction at right angles to the wall. The mean deflecting field was measured by compensating the deflexion locally by a weak magnetic field parallel to the wall. This ensured that the beam passed at a constant distance x from the wall, and enabled us to plot the d.c. field-intensity E_0 as a function of x. An example of such measurements is shown in Fig. 2. From the field E_0 it was possible to plot the d.c. potential profile $V_0(x)$ in the sheath, which corresponded approximately if not exactly to that calculated from the theories of Langmuir and Mott-Smith and Langmuir and Tonks.

After eliminating the static deflexion, the cathode-ray spot retained its elongated shape, which could scarcely be interpreted otherwise than as revealing the presence of an oscillating field, with a peak value $\hat{E}$, which is also plotted in Fig. 2 as a function of x. These observations were made in 1951 (E. A. A.[4]); but all attempts to prove the correctness of this interpretation failed until the end of 1954. It appeared an evident suggestion to detect the oscillations by passing the electron beam through a slit at right angles to the deflexion, catching it in a collector, and amplifying the oscillatory current. However, all that could be detected in this way was a low-frequency component in the oscillations, extending up to about 100 kc./sec., which could account only for a small fraction of the amplitude inferred from the deflexion. In the high-frequency region, which we explored up to 600 Mc./sec., it was impossible to detect any signal above the noise-level of the amplifiers, owing to the poor matching of the electron beam to ultra-high-frequency broad-band devices.

It was finally decided to try recording the oscillations directly on a photographic plate. This, as we realized beforehand and confirmed later, was an undertaking with only a marginal hope of success, because the exploring electron beam had to be kept very narrow (0·1 mm.) and was therefore very weak, with a current of about 0·1 μamp. The energy could not well be raised beyond 20 keV. if the deflexion sensitivity was to be kept at a reasonable level. A compromise was struck, at which the deflexion amplitude was a few spot diameters, and a record could just be obtained with the most sensitive plates available at sweep speeds of about 10^8 cm./sec. Thus we succeeded at last in demonstrating the existence of very-high-frequency oscillations in the boundary sheath, at least in arcs at 0·5–1μ pressure, where conditions are most favourable.

Some of the results are shown in Fig. 3. These oscillograms were taken in arcs with an electron concentration of $n = 3 \times 10^9$, electron temperature $T = 26{,}000°$. It is seen that in this case the phenomenon consists of a very-high-frequency oscillation of 100–120 Mc./sec., modulated by a noise-like band in the range 10–100 kc./sec. The first two oscillograms (Fig. 3*a*) show the envelope of the oscillation, as it appears on a long time-base; the irregular character of the modulation is well in evidence. Fig. 3*b* shows the very-high-frequency oscillation at maximum sweep-speed. The wave-form is not quite sinusoidal; its basic frequency is about 100 Mc./sec., which is not quite constant. It differed by about 20 per cent in oscillograms taken in rapid succession, but it is evident that the frequency is more nearly a constant than the amplitude.

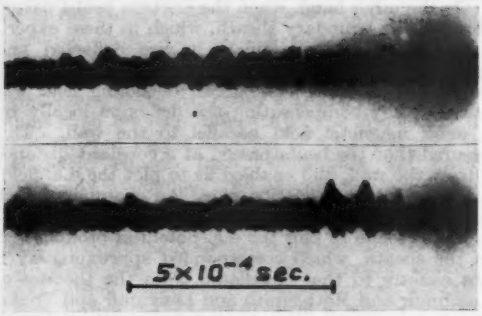

Fig. 3a. Two records of plasma-boundary oscillations on a long time-scale, showing the irregular character of the envelope

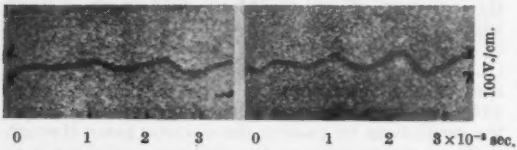

Fig. 3b. Two records of plasma-boundary oscillations on a very short time-scale, showing the basic frequency of about 100 Mc./sec.

In the gas-discharge field, it is often more expedient to ask first about the purpose of a phenomenon rather than for its causes. Gas discharges strike us as highly viable phenomena. In particular, it has been often remarked that the plasma tries to occupy as much of the discharge space as possible, and to secure its survival by a remarkable variety of mechanisms. For its survival the plasma of the positive column requires a certain small proportion of fast electrons, to replace by ionization the ion pairs lost at the wall. We see now that at pressures and at electron concentrations which are too low to produce the fast 'Maxwellian tail' by collisions, this is produced by interaction with the oscillating boundary sheath. The frequency of these oscillations is such that an electron diving into the sheath and emerging from it will spend just about a full cycle in it. This can be seen by approximating the part of the $V_s(x)$ curve near the sheath edge, which contains the major part of the electrons, by a parabola. It is well known that electrons in a parabolic potential trough oscillate with a frequency which is independent of their energy. In the case shown in Fig. 2, this works out to about 60 Mc. Hence during the time in which the electron dives into the sheath and returns again into the plasma, that is to say, performs one half-cycle of oscillation in the parabolic trough, the very-high-frequency field of 100–120 Mc./sec. goes nearly through a full cycle. Thus an electron diving into the sheath in the appropriate phase will gain energy both ways, and it can be seen from the data in Fig. 2 that this gain will be of the order of several electron volts. These electrons form the fast 'Maxwellian tail'. Their gain is balanced by the loss which other electrons suffer—those which dive into the sheath in the opposite phase. On balance, the electrons must lose a little energy to the oscillating sheath, because a certain amount of power is required to cover the losses; these, however, are very small because the boundary sheath is a resonator with small damping. As the oscillations are longitudinal, they do not radiate outwards, into the glass or metal envelope, nor are they propagated inwards, into the plasma, because their frequency is well below the critical plasma frequency ($f_p = 9{,}000\,n^{1/2}$). In the case shown in Fig. 3, the electron concentration was $n = 3 \times 10^9$/cm.^{3}; hence the plasma frequency was $f_p = 500$ Mc./sec. Thus the plasma-boundary frequency and its harmonics up to the fourth or fifth were well below it. Some losses are bound to arise, though, by the imperfect coherence of the boundary oscillations, that is to say, by their not vibrating in the same phase over large areas of the envelope.

Thus the oscillating boundary sheath is a very efficient energy exchanger, and there are good reasons for believing that it is this mechanism which maintains all low-pressure arcs in mercury and in other electropositive gases until the collision mechanism takes over. The experimental evidence regarding the point where the change-over takes place is not yet conclusive. Fig. 4 is a record of the various discharge data, n, T, the gradient G and the oscillating peak intensity $\hat{E}$, over a pressure range 0·5–3μ in mercury. It is seen that $\hat{E}$ falls gradually and becomes zero at the upper end of the pressure-range. This, however, we suggest interpreting as the failure of the electron probe method rather than a real fade-out of the boundary oscillations. In all our experiments the length of the movable wall was 2 cm., and it is very likely that, at the higher concentrations, and consequently thinner sheaths and higher frequencies, the boundary oscillations were no longer coherent over this length. In all probability they persist up to appreciably higher pressures and concentrations than those recorded in Fig. 4.

Turning now from the teleological to the causal interpretation of these oscillations, they appear to be of the 'reflex klystron' type, that is to say, they maintain themselves by the slight energy given up in the mean to the oscillating sheath by the returning electrons. (One could think that this energy is perhaps supplied by a slowing-down in the mean of the electrons which reach the wall, but we have found that the oscillations persist unaltered if the wall is made so strongly negative that not one electron in a million can reach it.) It is not so easy, though, to account for the remarkable fact that, unlike man-made klystrons which operate with

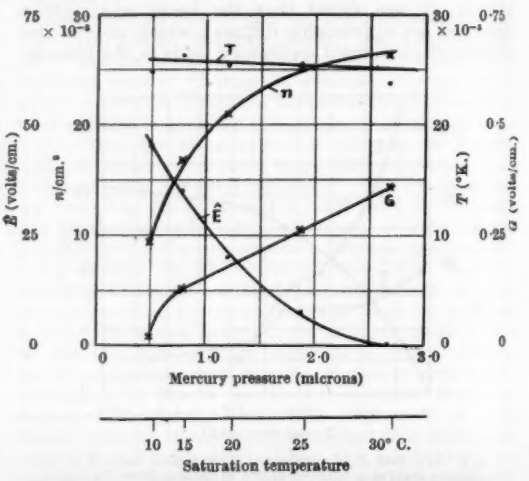

Fig. 4. Electron concentration n electron temperature T, gradient G and oscillating peak field-intensity $\hat{E}$ in a mercury arc with 100 m.amp. current, at various pressures

electrons of almost uniform energy, this oscillator operates so extremely near a thermal equilibrium that it is not easy to distinguish the electron energy distribution from the Maxwellian. In fact, the high-energy tail is so nearly Maxwellian that it cannot account for the oscillations; we attribute these to the small deficiency in slow electrons which we have regularly observed in probe measurements.

Though a detailed theory of this highly complicated and non-linear process is still being sought, its outlines are clear enough for venturing a generalization which may serve as a heuristic guide in searching for new phenomena: plasma-boundary oscillations are likely to arise at almost any boundary, not necessarily abrupt or permanent, which is in contact with a plasma however slightly off equilibrium. These oscillations constitute a powerful mixing, entropy-increasing mechanism, and as a by-product they might produce some radiation in all but cases of exceptional symmetry or regularity. What part, if any, they play in the generation of cosmic radio noise phenomena it is as yet too early to say.

[May 25

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EFFECTS OF GAMMA-RAYS ON SOLUTIONS OF SODIUM DEOXYRIBONUCLEATE

POSSIBLE CHEMICAL MECHANISM FOR THEIR BIOLOGICAL EFFECTS

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IT is well established that degradation of aqueous solutions of sodium deoxyribonucleate by ionizing radiations is an indirect effect due to radicals (OH· and HO_2·, in the presence of oxygen) formed by the breakdown of water[1–4]. Such radiations cause a decrease in the molecular weight[5] of the deoxyribonucleate with a consequent drop in the viscosity of the solutions. Previous viscosity studies[1,6–8] have been mainly confined to measurements of specific viscosity (η_{sp}) at one concentration and, over a limited range, log η_{sp} has often appeared to be a decreasing linear function of dosage[1,4]. From this it has been inferred[4] that the radicals attack the products of degradation; but strictly speaking it is only changes in the intrinsic viscosity $[\eta]$ $(=(\eta_{sp}/c)_{c\to 0})$ which are of significance in the estimation of molecular size and shape. Charlesby[9] has shown that such changes in $[\eta]$ can be related to characteristics of both the radiation process and of the polymer irradiated. The aim of the investigation now reported was twofold: to measure the intrinsic viscosity $[\eta]$ of deoxyribonucleate degraded by γ-rays in order to apply these theoretical considerations[9]; and to study more closely the chemical effects of dosages lower than those which previous workers[10–13] have shown to disrupt the constituent nucleotides of the deoxyribonucleate. There appears to be little knowledge concerning changes in this dose-range which is likely to be biologically more important. The latter problem was investigated by titration and other techniques. Titration studies are of particular value[13,14] in following the disappearance of the specific hydrogen bonds which cross-link the two constituent helices of sodium deoxyribonucleate in the solid state[15] and in solution[14].

Sodium deoxyribonucleate was prepared from herring sperm by water extraction of soft roes, and protein was completely removed from a saline solution (1 *M* sodium chloride) of the nucleoprotein by means of sodium dodecyl sulphate[16] followed by the method of Sevag[17]. Aqueous solutions of deoxyribonucleate (20 ml., 0·17–0·43 per cent) were subjected under standardized conditions to the radiation from a 100-curie cobalt-60 source (γ-rays, 1·25 MeV). After the irradiation, sodium chloride was added (to 0·1 *M* sodium chloride) and the solution left at 0° C. for a period sufficiently long (usually 24–30 hr.) for most of the 'after-effect'[2,3,7,8] on the viscosity to be complete. The flow times of this deoxyribonucleate solution in an Ubbelohde[18] viscometer were then measured at a series of dilutions. The solutions were Newtonian, and the viscosities obeyed the equation

$$\eta_{sp}/c = [\eta] + k'[\eta]^2 c$$

where c is concentration of deoxyribonucleate in gm./ml. and $k' = 0{\cdot}77$ (cf. the values of 0·77 and 0·73 predicted for extended chains[19] and rigid rods[20]).

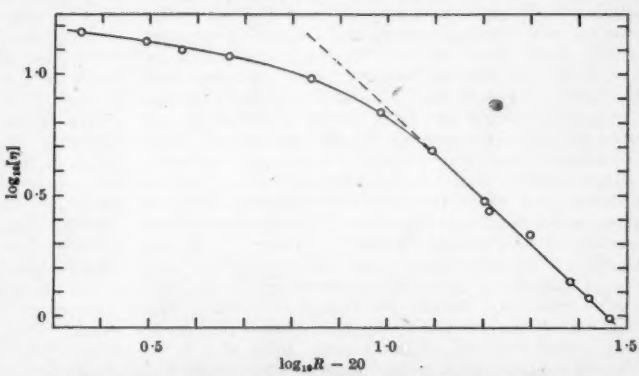

Fig. 1. Effect of γ-radiation on the intrinsic viscosity of herring sperm sodium deoxyribonucleate. Concentration of deoxyribonucleate during irradiation = 0·0043 gm./ml. Ordinate, log$_{10}[\eta]$, where $[\eta]$ is intrinsic viscosity in dl./gm. Abscissa, log$_{10}R$, where R is radiation dosage in eV. gm.$^{-1}$. Dose-rates employed in the range 1·1 to 1·3 × 10^{16} eV. min.$^{-1}$ ml.$^{-1}$. Slope of straight part of graph = − 1·86

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The viscosities of the irradiated samples were independent of rate of dose for a given dosage. They depended only on the ratio (denoted by R in eV. gm.$^{-1}$) of radiation dosage (in units of eV. ml.$^{-1}$ = $1{\cdot}72 \times 10^{-14}$ röntgens) to concentration of deoxyribonucleate (gm. ml.$^{-1}$) during irradiation, which again suggests an indirect effect (cf. ref. 21). The eventual linearity of a plot of log $[\eta]$ against log (R) (see Fig. 1) shows that the breakage must be random[9]. The slope of this linear portion of the curve is $-1{\cdot}86$ and, on the hypothesis of random cleavage of a single chain[9], is equal to the negative of the index α in the equation $[\eta] = KM_v^{\alpha}$, where K and α are constants for homologous polymers and M_v is the viscosity-average molecular weight. This relation arises because the probability, p_s, of a break in a single chain is $p_s \propto (R+R_0)$ and, when the molecular weight distribution is random, $M_v \propto (R+R_0)^{-1}$, that is, $M_v \propto R^{-1}$, when $R \gg R_0$, which applies over all the linear part of Fig. 1 (for definition of R_0 see ref. 9).

The value of 1·86 for the index α in the equation relating $[\eta]$ and M_v is improbably high, being greater than the values expected[22] either for rigid rods (1·7) or random coils (0·66), and indeed synthetic polymers rarely have α greater than 1. The basis of this interpretation is that every break in a monomer–monomer linkage leads to a change in molecular weight, and hence in $[\eta]$. In a cross-linked double helical structure such as the deoxyribonucleate, cleavage of a *single* monomer–monomer linkage (that is, an internucleotide bond) would not be expected to lead to an immediate change in molecular weight and intrinsic viscosity, $[\eta]$. Such changes would only happen if two breaks occurred in opposite positions, one in each of the two polynucleotide strands of the double helix (B and B', Fig. 2). It is of interest that the fragments so produced (B' in Fig. 2) are not unlike the interrupted double helical model suggested by Schachman and Dekker[4,5]. The joint probability, p_D, of such a complementary double break is $p_D = p_s^2 \propto (R+R_0)^2$. Hence $M_v \propto (R+R_0)^{-2}$ and the slope of the plot of log $[\eta]$ vs. log R will be (-2α) at $R \gg R_0$, which applies over all the linear part of Fig. 1. This gives a value for α of $1{\cdot}86/2 = 0{\cdot}93$, which is more feasible and is intermediate between the values for a rigid rod and for a random coil[22], in agreement with other observations on sodium deoxyribonucleate[24].

The evidence that, over the range of the viscosity studies, hydrogen bonds are still present holding the two helices together comes from titration studies, which show that, at the highest value of R in Fig. 1, 57 per cent of the hydrogen bonds are still present. In Fig. 3, curves I and II represent respectively the forward and back titration curves to and from pH 2·5 of the original deoxyribonucleate; (I) is the irreversible titration curve of a deoxyribonucleate with its adenine and cytosine amino-groups hydrogen-bonded, and (II) is the reversible titration curve of these same groups in 'denatured' deoxyribonucleate containing no hydrogen bonds[14]. Curves A, B, and C are the *forward* titration curves of various irradiated samples of deoxyribonucleate and show that γ-rays gradually destroy the hydrogen bonds. The back titration curves of the original (curve II, Fig. 3) and irradiated deoxyribonucleate (not shown in Fig. 3) indicate that acidic groups titrating at pH 4·5–5·5 and at pH 6·5–7 are released (for example, 0·22 group/4 moles of deoxyribonucleate phosphorus at $R = 1{\cdot}11 \times 10^{23}$ eV./gm.). These groups must comprise secondary phosphoryl end-groups, but may also include carboxyl groups at the C_5 of the sugar moiety produced by radical attack[25]. Curves A, B and C of Fig. 3 have all been corrected for these acidic end-groups, so that direct comparison can be made between them and (I) and (II).

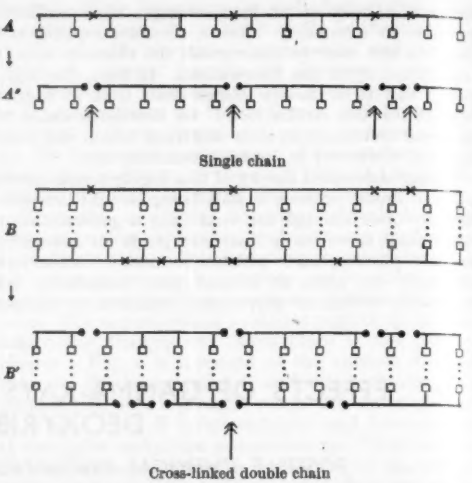

Fig. 2. Schematic diagram of the effects of random fracture of internucleotide linkages in sodium deoxyribonucleate according to two different models. (A) Single polynucleotide chain giving (A'). (B) Two polynucleotide chains cross-linked by hydrogen bonds, giving (B').
□, One nucleotide, the square denoting the purine or pyrimidine base; . . . , hydrogen bond systems cross-linking purines to pyrimidines; —●, new ends formed by the internucleotide breaks; ×, positions of fracture of internucleotide linkages; —»—, positions of breaks which alter the molecular weight and contribute to the decrease in $[\eta]$.
Both diagrams ($A \rightarrow A'$ and $B \rightarrow B'$) are drawn for a probability of rupture of an internucleotide linkage of 1/3. (Note bigger change in molecular weight for $A \rightarrow A'$)

An important feature of the titration curves (which is also clear from the lower part of Fig. 3) is that irradiation does not displace the forward titration curves uniformly from (I) towards (II) and without regard to the pH range, as would be expected for random breakage of all hydrogen bonds involving the titratable groups. In the early stages of irradiation, it is the lower part of (I) which is first displaced towards (II). This pH region corresponds chiefly to the titration of adenine amino-groups[14] in the intact molecule. (For clarity, Fig. 3 shows neither the five titration curves between (I) and A which accurately confirm the unsymmetrical character of this displacement, nor other curves between A and C.) As the irradiation proceeds (for example, curve B) the upper part of the curve is displaced towards (II), until eventually (for example, curve C) most of the hydrogen bonds are ruptured. It could be concluded from this that the adenine–thymine hydrogen bonded system[14] is broken down more rapidly than is the guanine–cytosine system and there is indeed no *a priori* reason why these two systems should have the same stability. However, it would contrast with the random breakage of the internucleotide bonds. Alternatively, the titration curves could be explained if the internucleotide breaks of Fig. 2 facilitated the irreversible denaturation of the deoxyribonucleate double helix so that fewer groups had to be ionized before complete denaturation. On the double helical model, breakage of hydrogen bonds by γ-rays would not lead to a change in molecular weight until the majority of such bonds

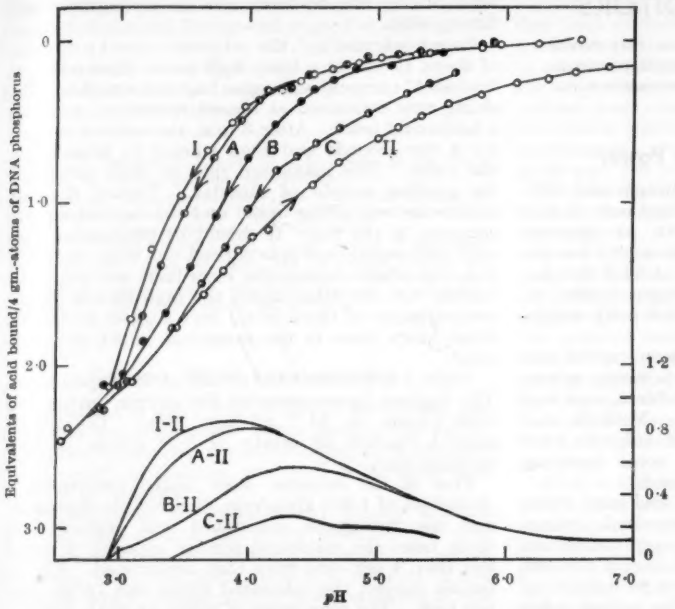

Fig. 3. Titration curves of original and γ-irradiated herring sperm sodium deoxyribonucleate. Titration conditions: 25° C., ionic strength = 0·05, concentration of deoxyribonucleate, 0·14–0·18 per cent.

Upper Figure. (I) and (II) forward (pH 6·0 to 2·5) and back (pH 2·5 to 7) titration curves of the original sodium deoxyribonucleate. *A*, *B* and *C*, forward titration curves (pH between 5 and 6 to pH 2·5) of deoxyribonucleate irradiated with γ-rays to different extents. Dosages, in units of (*R*): (*A*) $0{\cdot}37 \times 10^{20}$ eV. gm.$^{-1}$; (*B*) $2{\cdot}0 \times 10^{20}$ eV. gm.$^{-1}$; (*C*) $11{\cdot}5 \times 10^{20}$ eV. gm.$^{-1}$ Ordinate scale on the left.

Lower Figure. Difference curves obtained by subtracting the base bound along curve (II) from the other curves. Ordinate scale on lower right

had been ruptured, and this justifies the interpretation of changes of [η] in terms of rupture of internucleotide bonds over the range of *R* shown in Fig. 1.

As with other modes of degradation[26] which rupture hydrogen bonds, there is an increase in ultra-violet absorption of the sodium deoxyribonucleate at 258 mμ. It may be expressed as a percentage of the maximum increase in extinction, ε, observed with a high dosage ($R = 411 \times 10^{20}$ eV. gm.$^{-1}$) large enough to break all hydrogen bonds but not to decompose the purine and pyrimidine rings, and Table 1 shows that this quantity is approximately equal to the total percentage of hydrogen bonds broken (as deduced approximately from the titration curves). This is further evidence[27] that it is rupture of hydrogen bonds in the double helix which causes an increase in the ultra-violet absorption.

Table 1. Effect of Gamma-Rays on the Ultra-violet Absorption of Deoxyribonucleic Acid at 258 mμ

10^{-20} *R* (eV. gm.$^{-1}$)	28	29	35	111
Per cent increase in ultra-violet absorption, $\frac{\Delta\varepsilon}{\Delta\varepsilon_{max.}} \times 100$	40	50	45	78
Per cent hydrogen bonds broken (from titration)	38	42	43	80

It would appear that, as with some other studies of sodium deoxyribonucleate[14,24,26], the present results are best understood in terms of the existence of the double helical structure in aqueous solutions of deoxyribonucleate. The action of γ-rays consists of: (*a*) random cleavage of internucleotide phosphate ester bonds, a decrease in molecular weight and [η] resulting when two such breaks occur at opposite positions in each polynucleotide helix; and, (*b*), rupture of cross-linking hydrogen bonds, those which link the adenine–thymine pair of bases perhaps being broken more rapidly than those linking the guanine–cytosine pair. This rupture of hydrogen bonds begins at lower dosages than those causing appreciable changes in intrinsic viscosity and the even larger dosages causing degradation of the bases[10–12].

It has been suggested[27] that there is a relationship between the pairing of the bases linked by hydrogen bonds, the complementary nature of the two helices of the deoxyribonucleic acid that this implies, and the genetic self-duplicating role of deoxyribonucleic acid in biological systems. The effects of ionizing radiation on hydrogen bonding reported here show a possible chemical mechanism for the biological effects of low dosages of such radiation (and possibly also for mutational changes), since the rupture of a few hydrogen bonds would presumably impair the duplication of the deoxyribonucleic acid at that point but not elsewhere along the molecule.

We are indebted to Prof. M. Stacey for his interest and encouragement in this work and for making available the source of gamma-rays. We acknowledge also the co-operation of Dr. G. A. Gilbert in the viscosity measurements, and the receipt of a maintenance grant from the Department of Scientific and Industrial Research by one of us (R. A. C.). [Aug. 12

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LETTERS TO THE EDITORS

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New Records in Human Power

Under this heading Robinson, Edwards and Dill[1] published in 1937 results of investigations of five young men of international renown in distance running. Lash, who held the world's record for the 2-mile race, running on a treadmill at 21·6 km./hr. with no gradient, attained an oxygen intake of 5·35 l./min. or 81·5 ml. per kgm. of body-weight per min. [2].

In this laboratory, studies have been carried out on oxygen intake (aerobic capacity) during severe muscular work by normal, healthy children, men and women and championship athletes. Methods and results of examinations of about 260 subjects have been described by Åstrand[3,4]. In some cases an oxygen intake of 5 l./min. was obtained.

Table 1 gives the aerobic capacity and some other results for three international standard milers. Determinations of pulse-rate, pulmonary ventilation and oxygen intake were carried out during the last minutes of a 6-min. run at a speed of 20 km./hr. on a treadmill set at an angle of 1°. The highest value for oxygen intake was obtained with J. Landy, who broke the world's record in 1954 for the 1,500-m. race, that is, the same summer as that during which the present determinations were carried out. He reached an oxygen intake of 5·04 l./min. or 76·6 ml./kgm./min.

When testing the Swedish national ski-team for physical condition, submaximal work-loads were performed on a bicycle ergometer. Applying a nomogram[5], aerobic capacity was estimated from pulse-rate attained during this work. By this procedure, values of oxygen intake as high as 6·1 l./min. were estimated. As these figures far surpassed the earlier maximum, it was of great interest to obtain direct measurements of those subjects' aerobic capacity. Arrangements were therefore made to carry out some tests during the Swedish ski championships held during 1955.

To get 'warmed up', the subjects covered a distance of about 10 km. at a fairly high pace. Then a special 'rucksack' carrying a Douglas bag was attached. The skiing now continued at almost maximum speed on a horizontal track. After 3 min. the subject stopped for a few seconds and then started to breathe via the valve. The maximum rate of work proceeded for another couple of minutes. During the last minute he was skiing uphill and the expired air was collected in the bag. It should be emphasized that only one experiment was carried out with each subject, for which reason the recordings are minimum values. On the other hand, the high figures for the concentration of blood lactic acid suggest an oxygen intake very close to the maximum which is attainable[6].

Table 1 summarizes the results of the experiments. The highest figure recorded for oxygen intake was 5·88 l./min. or 81·7 ml./kgm./min. The female subject reached an intake of 3·97 l./min. or 68·4 ml./kgm./min.

Five of the subjects were tested performing a work-load of 1,200 kpm./min. on a bicycle ergometer, and the nomogram mentioned was applied. In three cases the estimated aerobic capacity diverged less than 4 per cent from that determined. For the female subject the estimated figure was 15 per cent too high. The nomogram is made up with different scales for men and women. When using the male scale for this very well-trained female skier, the estimated aerobic capacity, however, equalled that determined (4·0 l./min.).

In Table 1, values are included from an investigation of capacity for hard muscular work of eighty-six healthy, well-trained students of physical education[7]. None of those subjects, however, was of the championship class in events calling for endurance. The most striking difference between those students, on one hand, and the middle-distance runners and skiers, on the other, is found when comparing the capacity for oxygen intake. Values for vital capacity, maximum heart-rate, pulmonary ventilation and concentration of blood lactic acid were of the same order. It is probable that a high aerobic capacity

Table 1. Results of Measurements on Subjects performing Severe Muscular Work

Subjects	Body height (cm.)	Body weight (kgm.)	Vital capacity* (l.)	Heart-rate	Pulmonary ventilation* (l./min.)	Oxygen intake (l./min.)† determined	Oxygen intake (l./min.)† estimated‡	Oxygen intake ml./kgm./min. † determined	Blood lactic acid (mgm. per cent)	Work	Best result
Runners										Running	1,500 m.
♂ Landy, J.	179	66	5·8	194	133	5·04	—	76·6	108	20 km./hr.	3·41·8
♂ Karlsson, S.	172	62	5·7	200	119	4·53	—	73·0	102	1°	3·44·2
♂ Ericsson, I.	177	60	—	200	96	4·37	—	72·4	80	uphill	3·45·2
Skiers											15 km.§
♂ Jernberg, S.	177	72	8·1	179	146	5·88	6·1	81·7	92	Skiing	1
♂ Larsson, L.	174	67·5	5·8	182	111	5·49	6·1	81·3	81		2
♂ Larsson, P. E.	176	67	—	190	119	5·33	5·6	80·3	78		3
♂ Samuelsson, G.	183	68	—	182	150	5·34	—	78·5	122		10
♂ Gunnarsson, S.	175	67	5·7	179	130	5·30	5·4	79·1	82		4
♀ Eriksson, A. L.	160	58	4·1	188	105	3·97	4·6	68·4	110		10 km.§
											2
♂ 42 normal well-trained students	176·7±1·0 6·0‖	70·4±1·0 6·3	5·7±0·2 0·8	194±2 11	122±3 15	4·11±0·06 0·37	—	58·6±0·7 4·1	112±4 20	Running or cycling	
♀ 44 normal well-trained students	165·8±0·8 5·1‖	60·3±0·9 5·7	4·2±0·1 0·5	198±2 10	92±2 11	2·90±0·04 0·25	—	48·4±0·5 3·2	104±3 18		

* Volume at body temperature, ambient pressure and saturated.
† Volume at standard temperature, pressure and dry.
‡ From nomogram (ref. 5).
§ Swedish championship, 1955.
‖ Standard deviation (σ)

is an essential characteristic of people with a high standard of physical fitness with regard to endurance[6].

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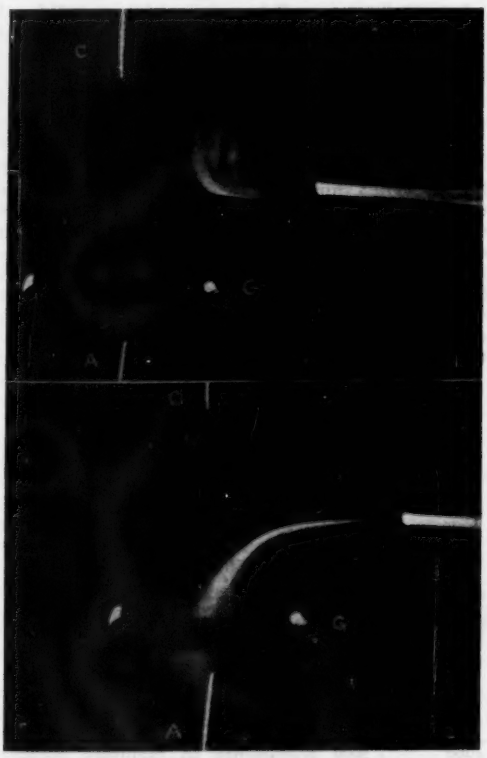
Corona Wind Loud-speaker

EXPERIMENTS made with a pair of electrodes, one sharp and one blunt, show that a corona wind moves away from the sharp point independent of its polarity. If the needle is positive, the wind is stronger than when it is negative.

The wind may be controlled by placing a blunt ring or 'grid' around the sharp electrode: if this ring is maintained at the same order of voltage as the sharp electrode, then there is a position of the latter at which comparatively small changes of the grid potential produce a maximum effect on the intensity of the corona wind and hence on the corona current. This may be explained on the assumption that lines of force which otherwise would terminate on the tip of the needle are deflected to the grid ring to an extent dependent on the relative potentials of the electrodes. Thus although the grid takes no current itself, variations of its potential can control the corona current over a wide range. An extensive experimental study of this phenomenon has been made and will be published elsewhere.



(1) Strong positive wind from needle A; $V_{AG} = 17{\cdot}5$ kV. and $V_{GC} = 8{\cdot}5$ kV. (2) Strong negative wind from needle C; $V_{AC} = 18{\cdot}6$ kV. and $V_{GC} = 15{\cdot}2$ kV.

With two sharp electrodes A, C (Fig. 1) opposed to each other, the strong positive wind greatly exceeds the negative. The interaction of the two winds causes an injected smoke stream from the region of the positive needle to avoid the negative one in an umbrella-shaped form (not shown) near the negative needle. If now the ring electrode G is placed around the positive needle A, the positive wind may be completely cut off (Fig. 2), in which case the negative wind predominates. With a positive wind adjusted to equality with the negative there is no net wind.

An alternating potential applied to the grid causes the air to pulsate and hence to become a source of sound.

With a stacked array of triodes large enough to give a reasonable acoustic area, the device becomes a loud-speaker with certain distinctive features. (*a*) It has no moving parts. (*b*) It requires no electrical power at acoustic frequencies to drive it, since the 'grid' ring takes no current. The power comes from a d.c. source across the needles. (*c*) It has a good bass response, without any bass resonance even down to zero frequency: the steady wind is the zero-frequency response. (*d*) It has a good middle- and high-frequency response smooth to 15 kc./s. (*e*) In its present form it has a severe limitation in its linearity; but a push–pull form is under construction. (*f*) Its power output under an approximately linear adjustment is about 0·1 mW. per sq. cm. of matrix area, a figure comparable with types of electrostatic loud-speaker using diaphragms. The d.c. power input is about 50 mW. per sq. cm. at 12 kV. (*g*) The polar distribution of sound may be varied at will by varying the shape of the matrix. It does not need to be planar.

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July 6.

Magnetic Moment of an Excited State of the Fluorine-19 Nucleus

THERE is a well-known technique[1] for the measurement of magnetic moments of short-lived nuclear states. A strong external magnetic field applied to a radioactive source which emits γ-rays in a cascade process will influence the nuclear spin of the intermediate state, and thus change the γ−γ angular correlation. The strength of the interaction is a measure of the nuclear moment, and the theory of the process has been worked out[2,3].

The same principle has been applied to a study of the angular distribution of γ-rays resulting from the nuclear reaction:

$$p + {}^{19}\mathrm{F} \rightarrow p' + {}^{19}\mathrm{F}^{**} \rightarrow p' + \gamma + {}^{19}\mathrm{F} \qquad (1)$$

where the intermediate nucleus ($^{19}F^{**}$) is known[4] to have a lifetime of $(1{\cdot}0 \pm 0{\cdot}2) \times 10^{-7}$ sec., spin 5/2 and excitation 197 keV. A uniform vertical magnetic field was applied normal to the beam of the Canberra H.T. set, and protons of 873 keV. were allowed to

strike a target of sodium fluoride (0·3 mgm./cm.²) evaporated on copper. Gamma-rays were detected at different angles in a horizontal plane with a photomultiplier (employing a 1-in. diameter × ½-in. sodium iodide (thallium) crystal) mounted on a rotatable table, and the pulse spectrum was recorded on a kicksorter.

Fig. 1 shows the experimental results and a theoretical plot of the function

$$\frac{W(0°) - W(100°)}{W(0°) + W(100°)} = a\,\frac{0{\cdot}97 - 0{\cdot}17x}{1 + x^2} \qquad (2)$$

which approximates (to within ± 2 per cent) to a formula given by Alder[3]. This formula (calculated for $\gamma-\gamma$ correlations) can be shown to apply to the present case since (i) one averages over (p' + $^{19}F^{**}$) directions and (ii) the angular distribution function[5] is, in the absence of external fields, of form:

$$W(\theta) = 1 + A\cos^2\theta$$

where $A = \frac{2a}{1-a}$. In equation (2), $x = 2g\mu H\tau/\hbar$, where these quantities have meanings given by Alder. The solid and dotted curves correspond to $g = +1{\cdot}35$ and $g = -1{\cdot}90$ respectively.

If one assumes, on the basis of the nuclear shell model, that the 197-keV. level approximates to an odd $d_{3/2}$ proton orbit, the Schmidt value[6] for the g-factor is + 1·9171. Thus, we accept the positive result and, taking account of errors in this experiment and the life-time measurement,

$$g\ (197\ \text{keV. level}) = +\ (1{\cdot}35 \pm 0{\cdot}35).$$

A decoupling experiment[7] in which a magnetic field of 8,000 oersteds was applied along the beam axis failed to increase the anisotropy factor A above the zero-field value 0·42 ± 0·02, so one may assume that the fluorine-19 nucleus was not magnetically coupled in the sodium fluoride target. Using a manganese fluoride target, however, a value $A = 0{\cdot}10 \pm 0{\cdot}02$ was obtained; but a decoupling experiment again failed to restore any anisotropy. In this case the extranuclear influence at work may be electronic paramagnetic relaxation, though the shortness of relaxation time in manganese fluoride makes this improbable[8]. If, as seems likely, the tetragonal symmetry of manganese fluoride results in anisotropic hyperfine structure, a decoupling field can have little influence. In support of this, the reduction of A from 0·42 to 0·10 is just what would be expected[3] were strong anisotropic hyperfine structure present in a random arrangement of microcrystals. A third possible explanation is that quadrupole interactions are present: this could only be investigated using single crystals.

Further experiments are proceeding, and this work will be reported more fully elsewhere.

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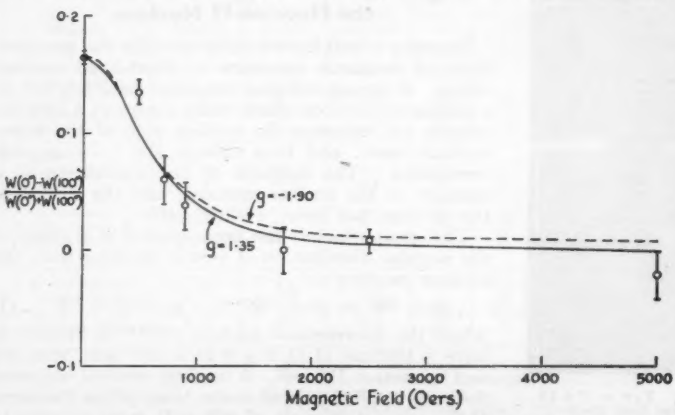

Fig. 1. Anisotropy as a function of the magnetic field-strength

Thermal Expansion of Coal

The following observations, which form part of an investigation into the pore structure and surface area of coal, are reported here in view of the current interest[1,2] in the expansion moduli of coal.

Table 1

Coal	Carbon (per cent, dry, ash-free)	Volatile matter (per cent, air-dry)	Mean linear coefficient ($\bar{\alpha} \times 10^4$)
New Cross Hands	93·8	5·5	24·2
Cefn Coed	93·0	6·5	25·4
Cwmgwrach	91·8	9·5	28·7
Deep Navigation	91·3	14·7	31·0
Pochin	91·1	19·5	33·2
Wyllie	89·1	25·0	35·4
Beynon	87·4	30·2	37·9
Cwm Carn	84·5	35·5	39·1
Ellington	79·4	33·0	37·1

The bulk modulus of expansion of a series of coals has been determined by a dilatometric method in which about 40 gm. of bright coal (10–18 mesh B.S. test sieve) was confined under a mercury–thallium amalgam in a steel bomb, and the expansion observed by the change in height of the amalgam in a 70-cm. length of precision-bore tubing of 1·5 mm. internal diameter. Calibration was effected by measurements with the dilatometer empty of coal, and the accuracy of the method confirmed by measurements with 10–18 mesh (B.S. test sieve) borosilicate glass of known modulus.

The temperature-range was 0° to − 47° C., covered by using a series of eight refrigerant baths, in which the steel bomb was immersed up to the junction with the precision-bore glass tubing. With the exception of the Ellington coal, all the coals examined were from the South Wales Nine Foot Seam, which is believed to represent coals of the same origin in widely different states of coalification.

Results for all the samples used are shown in Table 1, the expansions being given as mean linear coefficients to facilitate comparison with the results of other workers.

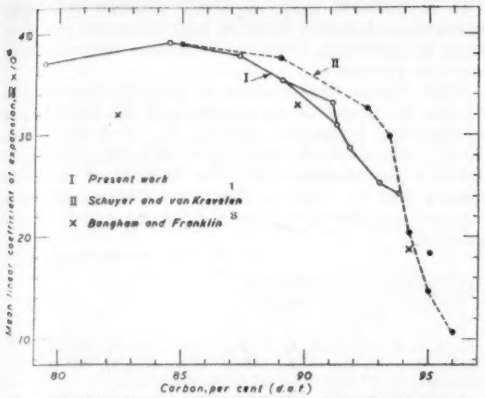

Fig. 1. Relationship between thermal expansion and rank of coal

It should be noted that the expansion coefficient appears to be even better related to the volatile matter than to the carbon content.

The results are shown graphically in Fig. 1. The broken line has been calculated from the results of Schuyer and van Krevelen[1] for expansions perpendicular and parallel to the bedding plane, assuming the expansion to be isotropic in the latter plane. The agreement between the two main sets of independent observations is better than usually expected for measurements on coals of different origin. The values found by Macrae and Ryder[2] refer only to the expansion parallel to the bedding plane and are too large to be included on this graph; but it is interesting to note that the different results obtained by them for two samples of the same coal, measured parallel to the bedding plane, could mean that anthracite is anisotropic in all three major planes. This is not well supported, however, by the agreement, already mentioned, between the mean coefficients obtained by direct observation of the cubical moduli and those calculated from the separately measured parallel and perpendicular moduli.

A full description of the apparatus, and a discussion of the results will appear elsewhere.

This work forms part of the programme of research of the Fuel Research Board of the Department of Scientific and Industrial Research, and is published by permission of the Director of Fuel Research.

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Separation of Ions at Crystallization of Water

According to Workman and Drost-Hansen[1], a substantial amount of fluorine ions is incorporated into ice if it is crystallized from diluted solutions of cæsium fluoride. We have studied this process further, and found that it is not fluorine ions which are incorporated into ice but rather electrically neutral molecules of hydrogen fluoride.

One half of a diluted solution of cæsium fluoride in water was frozen and the ice separated from the remaining liquid. The water used had been distilled in a vacuum and was free of impurities, especially carbon dioxide. The *p*H of the remaining liquid was found to be higher than that of the thawed ice. An example is given in Table 1.

Table 1

Sample	mol. F′/l.	*p*H	F′ (mgm./10 cm.³)
Original solution	$5{\cdot}82 \times 10^{-4}$	8·0	1·105
Non-frozen liquid	$8{\cdot}42 \times 10^{-4}$	8·5	1·658
Ice	$9{\cdot}7 \times 10^{-4}$	7·0	0·184

The accuracy of these measurements was not very high because the determination of the *p*H-value was carried out by means of an indicator. We are now carrying out more precise measurements.

The above experiments agree with results on the incorporation of hydrogen fluoride into ice. We found that small quantities of hydrogen fluoride can be built into the ice lattice. According to previous investigations[2], ammonium fluoride forms mixed crystals with ice in a range up to about 10 per cent ammonium fluoride. The replacement of water molecules in ice by ammonium fluoride seems to be facilitated by the fact that the ratio H/(N+F) is the same as the ratio H/O in water. Since, if water molecules are replaced by hydrogen fluoride, this ratio is smaller than 2 : 1, a greater disturbance by missing hydrogen bonds is introduced if water is replaced by hydrogen fluoride. This exemplifies the great influence of hydrogen bonds on the stability of the ice lattice.

This investigation was carried out under a contract of the Snow, Ice and Permafrost Research Establishment, Corps of Engineers, U.S. Army.

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Magnetic Catalysis of the Decarboxylation of Oxaloacetic Acid

Kinetic studies of the decarboxylation of phenylmalonic acid in aqueous solution in the presence of high concentrations of rare-earth ions show that diamagnetic ions have little effect on the rate of reaction, while the paramagnetic dysprosium ion leads to an acceleration in rate of the order of 10 per cent[1,2]. Rare-earth ions do not appear to become co-ordinated appreciably with phenylmalonic acid. Since any magnetic effect must be a very sensitive function of the distance between catalyst and substrate, a study is now being made of the kinetics of decarboxylation of an acid, the anions of which are known to become co-ordinated more strongly with metal ions.

The kinetics of decarboxylation of oxaloacetic acid and its anions have been investigated by Pedersen[3]. We have now measured the rates of decarboxylation of this acid in aqueous solution at 37° in the presence of lanthanum, gadolinium, yttrium, dysprosium and lutecium ions (Clayton, J. P., and Gelles, E., unpublished results). The manometric method[4] employed for following the evolution of carbon dioxide yields first-order rate coefficients accurate to ± 3 per cent. *p*H measurements show that the thermodynamic dissociation constants $(M^{3+})\ (A^{=})/(MA^{+})$, where M^{3+} represents

a rare-earth ion and $A^{=}$ the divalent oxaloacetate anion, are around 2×10^{-6} at 25° (Gelles, E., and Nancollas, G. H., unpublished results). At the concentrations used in the kinetic experiments, a small fraction of the oxaloacetic acid is in the form of rare-earth complex; but with constant initial conditions of concentration and *p*H, the concentrations of uncomplexed species are effectively constant for different rare earths.

The effect of the rare-earth ions on the rate of decarboxylation might be expected to be a smooth function of the chemical activity of the ions. A linear free-energy relationship between rate and equilibrium data is indeed found for the diamagnetic ions. Fig. 1 shows a plot of the logarithms of the first-order rate coefficients ($\log_{10}$, min.$^{-1}$) in a typical set of experiments against the logarithms of the thermodynamic stability constants of the rare-earth ethylenediaminetetra-acetates[5]. In the set of kinetic experiments, the initial *p*H was constant at 1·02, and the initial concentrations in moles/litre of oxaloacetic acid and rare-earth ion were 0·0300 and 0·100 respectively. The reaction-rate is due almost entirely to the complexed species, the rate coefficients used in Fig. 1 being corrected for the small amount of uncatalysed reaction. Size of circle indicates the probable limits of experimental errors. It is seen that for the diamagnetic ions La^{3+}, Y^{3+} and $^{7}Lu^{3+}$, an excellent linear free-energy relation is found.

For the paramagnetic ions Gd^{3+} and Dy^{3+}, an acceleration in rate of decarboxylation is observed greater than that predicted by interpolation from the linear free-energy relationship. For Gd^{3+} it is about 20 per cent, and for Dy^{3+} about 10 per cent. This additional catalysis by the paramagnetic ions increases with increasing ion concentration, and it can be attributed specifically to the presence of unpaired $4f$ electrons in these ions.

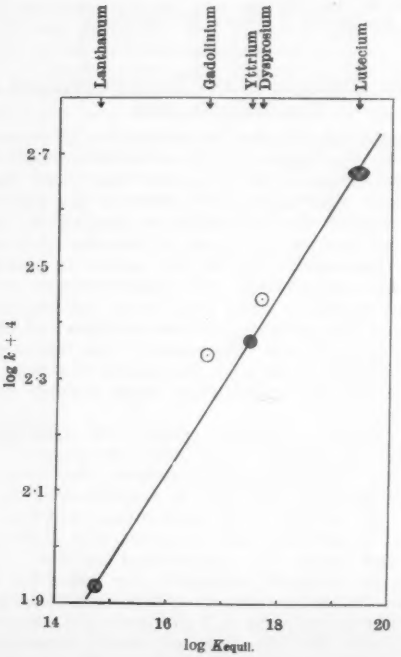

Fig. 1

It is possible that unpaired electron spin–spin interactions between catalyst and substrate result in some contribution from a favourable non-adiabatic reaction process.

With further kinetic data at lower concentrations (Gelles, E., unpublished results) and the appropriate equilibrium constants (Gelles, E., and Nancollas, G. H., unpublished results), it will be possible to obtain rate-constants for the individual complex species and to make a direct comparison between rate and equilibrium properties for one and the same substrate.

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May 9.

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Cosmic Sources of Deep-Sea Deposits

Black magnetic spherules found in deposits collected by the *Challenger* Expedition (1872–76) have been recognized as being probably of cosmic origin[1]. These spherules represent but a very small fraction of the sediments by mass, and have little effect on their average chemical composition. The relatively high nickel content of deep-sea deposits in the Pacific Ocean led Pettersson and Rotschi[2] to suggest a cosmic origin for the excess nickel. The amount of accretion of cosmic matter by the earth required to account for this excess would not conflict with some estimates of the density of matter in the zodiacal-light cloud[3], although other estimates would fall short of the requirements.

The frequency of spherule diameters[4], extracted from samples of deposits obtained by the Swedish Deep-Sea Expedition, showed excellent agreement with the theoretical frequency for micro-meteors[3], for the following distribution of velocities:

Velocity (km./sec.)	11·5	13·2	16·9	All
Percentage	33·3	16·7	50·0	100·0

The velocity-range is close to what would be expected for primordial dust, spiralling into the sun under the Poynting–Robertson effect[5], in direct motion and in orbits of small eccentricity. The main component of the velocity is due to the earth's attraction, which sets 10·8 km./sec. as a lower limit to it. The agreement of the frequency of diameters with theory lends support to the hypothesis that the spherules are of cosmic origin.

However, the cosmic origin of the general nickel excess has been subjected to doubt by Laevastu and Mellis[4], on the basis of the ratio of iron to nickel, and by Smales and Wiseman[6], from the relative abundance of nickel, cobalt and copper. The relative abundances of these elements agree with those of terrestrial sources, and greatly disagree with those of meteorites. Laevastu and Mellis suggest that iron and nickel in the oceanic red clay may be due in part to co-precipitation from sea water.

Nevertheless, the conclusion that the excess nickel is not of cosmic origin would be premature. Meteorites are believed to be fragments of larger bodies—planets—destroyed in collisions; in such a case they are the product of astrochemical differentiation in the interior of the planet, which preceded the

Table 1. Average Abundance Ratios of Iron, Nickel, Cobalt and Copper

	Fe/Ni	Ni/Co	Ni/Cu
Deep-sea red clay (ref. 6)	—	3·1	0·85
Globigerina ooze (ref. 6)	—	4·1	0·77
Pacific deep-sea core (ref. 4)	100	—	—
Oceanic rocks (ref. 6)	—	4·3	1·2
Solar atmosphere (Russell; Unsöld)	16 ; 50	2·5 ; 8	10 ; 50
Earth's crust (Clarke and Washington)	250	10	0·3
Meteorites (Goldschmidt; Noddack)	19 ; 14	13 ; 16	90 ; 100

catastrophe and led to the peculiar distribution of the abundances, according to the conditions in the interior and the physico-chemical properties of the elements. On the other hand, the fine primordial dust is most properly described as the product of condensation from a gaseous medium; there is no good reason for assuming that in this case the selection of the elements would be identical with that in meteorites; on the contrary, the composition of the surface layers of the earth and the solar atmosphere could be expected to be more akin than meteorites to that of the primordial dust.

The distinction between meteorites and meteoric dust is not only a theoretical one. An analysis of meteor observations, obtained during the Arizona Expedition[7], indicates that the great majority of naked-eye meteors are fluffy or spongy 'dustballs' which decompose, not by vaporization or spraying from a solid dense nucleus, but simply by crumbling under an aerodynamic pressure as low as 10^4 dyne/cm.^{2}. Recent results from Harvard Super-Schmidt photographs confirm this[8]. The small meteors are probably similar to snowflakes—the results of sublimation from a gaseous state. Whipple's theory of cometary structure visualizes such substance, intermingled with 'ices'; near the sun the more volatile ices have evaporated, and 'dustball' skeletons remain, observed as naked-eye and fainter meteors when they enter our atmosphere.

These facts indicate the need for caution in applying the meteoritic analogy to the chemical composition of amorphous cosmic matter, such as would collect on the bottom of the sea.

In Table 1 the meteoritic abundances are compared with terrestrial and other cosmic abundances. The data would vary according to source; nevertheless, the sets chosen are quite characteristic. The increased abundance ratio nickel to iron in the Pacific core, as compared with the earth's crust, is noticeable. Although the terrestrial abundances agree best with those of the deep-sea deposits, this would not necessarily mean a terrestrial origin of the latter; it may be that the earth's outer crust itself, being the last addition to our planet from cosmic sources, is built of a material the remnants of which are still falling on the earth from the zodiacal-light cloud.

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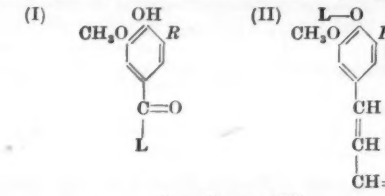
Contribution of Residues containing Carbonyl to the Ultra-Violet Absorption of Lignins

Absorption spectra and colour reactions indicate the presence in lignins of *p*-hydroxyphenylketone groups (I; L represents the rest of the lignin molecule)[1] and 4-O-substituted cinnamaldehyde groups (II)[2].



R = H, or OCH_3

Both types of carbonyl-containing residues have an absorption band near 350 mμ, but it has been found possible to distinguish such groups by their different rates of reduction with sodium borohydride in dilute (0·01 *N*) sodium hydroxide.

Table 1. Reductions with Sodium Borohydride

Solutions of the following molarity in 0·01 *N* sodium hydroxide were used. *iso*-Vanillin, 2×10^{-4} *M*; acetovanillone, veratric aldehyde, 5×10^{-5} *M*; *p*-hydroxybenzaldehyde, vanillin, syringaldehyde, ferulic aldehyde, 3 : 4-dimethoxycinnamaldehyde, 2×10^{-5} *M*. Each solution (2 c.c.) was mixed with 0·2 *M* sodium borohydride in 0·01 *N* sodium hydroxide (1 c.c.), and the reaction followed spectrophotometrically at suitable wave-lengths in a 1-cm. cell. Temperature 20°

Substance	Half-reaction time (min.)
3 : 4-Dimethoxycinnamaldehyde	1
Veratric aldehyde	2
iso-Vanillin	20
Ferulic aldehyde	56
Vanillin	116
p-Hydroxybenzaldehyde	139
Syringaldehyde	156
Acetovanillone	1,180

Carbonyl compounds which are phenolic and ionized in 0·01 *N* sodium hydroxide are reduced more slowly; though in *iso*-vanillin, with the carbonyl in the meta position, this effect is least marked.

With four 'native' lignins, the effect of reduction with sodium borohydride is in each case a diminution in extinction in the 350-mμ region. Two stages can be discerned in this: a rapid stage concluded in about thirty minutes, and a slower stage lasting many hours (Fig. 1). Comparison of rates of reduction with those described in Table 1 makes it seem likely that the groups reduced in the rapid stage belong to the non-ionized category. 3 : 4-Dimethoxycinnamaldehyde has an absorption band in the correct position (335 mμ; giving on reduction 3 : 4-dimethoxycinnamyl alcohol with absorption bands at 260 mμ and 290 mμ), and this is consistent with the presence of rapidly reduced groups of type II in these four lignins.

The analogy between these groups and 3 : 4-dimethoxycinnamaldehyde was strengthened in the case of aspen by a consideration of the effect of *N* sodium hydroxide. In this reagent, 3 : 4-dimethoxycinnamaldehyde is decomposed with a half-reaction time of 55 min. at 20° to veratric aldehyde, which has absorption maxima at 277 mμ and 306 mμ, so that the absorption in the 340–350 mμ region diminishes to zero. The extinction of aspen 'native' lignin in the region of 340–350 mμ diminishes by 40 per cent under the same conditions with a half-reaction time of 60 min. These similarities of behaviour in *N* sodium hydroxide suggest that a like process may be occurring in both cases, and that groups of type II in aspen 'native' lignin may undergo a reversed-aldol reaction in *N* sodium hydroxide with the elimination of acetaldehyde.

Table 2

	E(1%, 1 cm.) at 350 mμ due to :			
	Extinction of groups rapidly reduced by sod. borohydride (Groups of type II)	Residual extinction (Groups of type I)	Extinction in weakly acid solution (Groups of type II)	Difference in extinction between alkaline and weakly acid solution (Groups of type I)
Aspen 'native' lignin	33·3	16·8	31·9	18·3
Horse chestnut 'native' lignin	9·7	71·2	18·3	62·2

The second stage in the reduction of the four 'native' lignins by sodium borohydride in 0·01 *N* sodium hydroxide consists of a very slow further diminution in absorption at 350 mμ. In the case of aspen and horse chestnut lignins, the absorption in this region is eventually removed almost completely, and the wave-lengths of absorption and rates of reduction of the slowly reduced groups are both consistent with their having structures of type I. If this is so, then the two lignins in question show great contrast in the relative amounts, measured in terms of extinction at 350 mμ, of groups of types I and II. A check on this is provided by an examination of the absorption spectra of these lignins in acid and in alkaline solutions. Groups of type I absorb at 350 mμ only when ionized, whereas groups of type II absorb at 350 mμ at all *p*H's. The figures obtained by this method are compared with the figures obtained by reduction with sodium borohydride in Table 2.

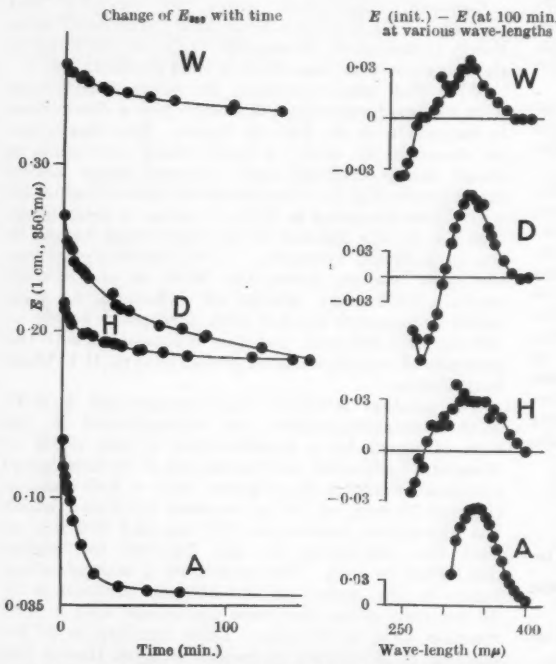


Fig. 1. The rapid stage in the reduction of 'native' lignins with sodium borohydride in 0·01 *N* sodium hydroxide. Concentration of each lignin, 2·67 × 10^{-2} gm./100 c.c.; concentration of sodium borohydride, 2·59 × 10^{-2} gm./100 c.c.; temperature, 20°. *W*, wheat straw native lignin; *D*, douglas fir native lignin; *H*, horse chestnut native lignin; *A*, aspen native lignin

It can be seen that there is a reasonable agreement between the relative amounts of groups I and II calculated by each method.

While the conclusions reached must be regarded as tentative, depending as they do entirely on spectrophotometric measurements, yet it seems that reduction with sodium borohydride, followed spectrophotometrically, offers a convenient method of measuring cinnamaldehyde groups in 'native' lignins. The diminution in absorption at 350 mμ is only an index of these groups, since the exact extinction and wave-length of maximum absorption will vary depending on whether R = H, or OMe.

This work forms part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

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Chlorophyll Spectra and Molecular Structure

During experiments on pigment orientation in chloroplasts and grana, it was necessary to determine the directions in which linearly polarized light is preferably absorbed in a pigment molecule. This preference corresponds to the directions of maximum transition probability of the electronic transitions which give rise to the different absorption bands in the spectra. By studying dichroism and polarization of fluorescence for chlorophyll *a*, *b*, bacteriochlorophyll and the corresponding phæophytins, these directions have been investigated.

Dichroism. Pigments were oriented in lecithin or ammonium oleate by pressing between a microscope slide and a cover glass. Absorption was measured with a barrier-layer photocell or photographically. For planar molecules of approximate symmetrical shape, such as the porphin derivatives, it is in this way possible to distinguish between absorption in, or perpendicular to, the plane of the molecule. For the chlorophylls mentioned, it was concluded that absorption occurs in the plane of the porphin heads in the spectral region from 750 to 400 mμ.

Polarization of fluorescence. In Fig. 1 the polarization and absorption spectra of bacteriochlorophyll and bacteriophæophytin and in Fig. 2 those of chlorophyll *a* and phæophytin *a* are presented. The observations show that the direction of the transition responsible for the band at 590 mμ in bacteriochlorophyll is situated perpendicular to the transition direction at 780 mμ. In bacteriophæophytin the band at 590 mμ is shifted to 535 mμ.

The chlorophyll *a* spectrum shows a band due to a second transition at 580 mμ. At this wave-length the absorption due to the second transition overlaps the tail of the bands due to transition I. This is shown in the fluorescence spectrum, which is to a good approximation a mirror image of the absorption bands of I. Taking this overlap into account, it can be calculated that in chlorophyll *a* also

Table 1

Transition	Measured			Calculated		
	Orient.	λ(mμ)	εrel.	Orient.	λ(mμ)	εrel.
I	⊥	765	70	⊥	1,150	100
II	∥	530	30	∥	620	100
III	⊥	(460)	< 5	⊥	450	100
IV	∥	385	60	∥	435	100
V	⊥	365	100	⊥	330	100

transition II is perpendicular to I. In phæophytin *a*, transition II is shifted to 525 mμ.

The values of p in the Soret band of chlorophyll *a* indicate that, contrary to the views of Perrin[1] and Stupp and Kuhn[2], here also there is overlapping of two transitions: one with a maximum at 435 mμ perpendicular to I, and one with a maximum at 415 mμ parallel to I. In bacteriochlorophyll also, the Soret band is most probably caused by two transitions, one at 390 mμ perpendicular to I and one at 360 mμ parallel to I.

The maximum at 510 mμ in the polarization spectra of bacteriochlorophyll and bacteriophæophytin may be ascribed to a separate transition with a small transition probability. In phæophytin *a* and *b* the maximum in this spectral region corresponds to an absorption band of measurable intensity.

Longuet-Higgins[3] and Platt[4] have calculated spectral data for the conjugated ring structures of tetrahydroporphin ('long-field' spectrum) and porphin ('round-field' spectrum) on the basis of the molecular orbital theory. In Table 1 the values of orientation, wave-length (λ) and maximum extinction coefficient (ε) measured and calculated are compared for bacteriophæophytin and tetrahydroporphin.

The measurements do not give an absolute orientation of transition I in the porphin plane. For various reasons the authors mentioned assumed transition I to vibrate perpendicular to the elongation of the conjugated system. This suggestion was supported by the fact that transition II, vibrating parallel to this elongation, is shifted but slightly when changing from bacteriophæophytin into phæophytin *a*. [Chlorophyll *b* showed a somewhat less pronounced polarization spectrum, being closer to a 'round-field' spectrum than chlorophyll *a*.

A full account of these and related measurements will be published elsewhere.

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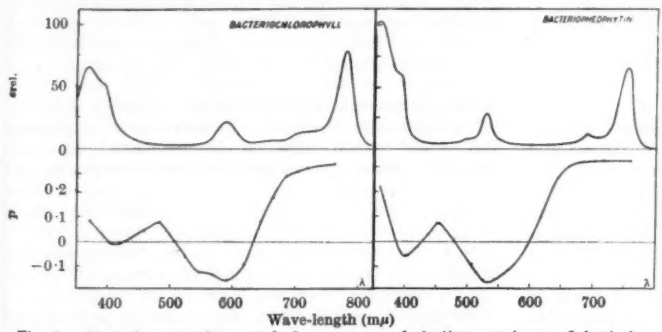

Fig. 1. Absorption spectrum and fluorescence polarization spectrum of bacteriochlorophyll and bacteriophæophytin in *cyclo*hexanol ($\eta = 0{\cdot}66$). εrel. denotes relative extinction coefficient; p is degree of polarization

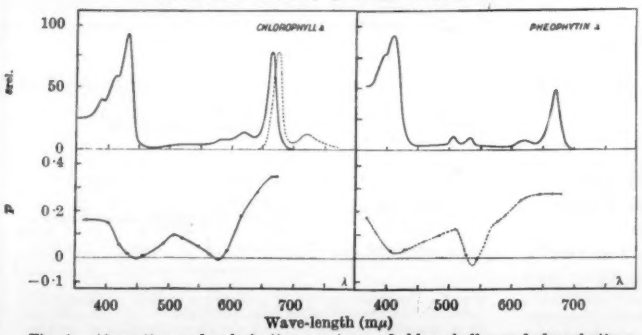

Fig. 2. Absorption and polarization spectrum of chlorophyll *a* and phæophytin *a*

Use of Acid-Base Indicator for Quantitative Paper Chromatography of Sugars

Quantitative methods of paper chromatography tend to be unsatisfactory largely because of the very small amounts of substance separated. In the case of sugars, the spots are generally located by guide strips, which are an additional source of inaccuracy. Giri[1] has recently shown that relatively large amounts of sugars can be separated by circular chromatography. The same author and Parihar[2] attempted to recover the sugars by running the solvent off the paper and collecting it in fractions; however, they did not achieve quantitative separation.

In the method described here, the sugars are separated by circular chromatography and are then shown up by an acid-base indicator. The latter does not destroy the sugars, which can then be cut out, eluted from the paper and estimated.

The solution under test is applied to the centre of a Whatman No. 3 paper (17 cm. diameter); 0·2 ml. containing up to 50 mgm. total sugars was found to be suitable. The paper is dried and a wick put through the centre. It is then developed in the normal way, using a desiccator as the cabinet. The desiccator has a clock glass in place of the usual wire gauze, and resting on this is a Petri dish serving as solvent reservoir. More solvent is placed in the bottom of the desiccator to saturate the atmosphere.

After developing, the paper is dried well and sprayed with an indicator solution of the following composition: 40 mgm. bromocresol purple and 100 mgm. boric acid dissolved in 100 ml. methanol to which 7·5 ml. of 1 per cent borax solution is then added. Sugars are shown up yellow against a blue background. The colour difference fades in a few minutes and the position of the sugars is therefore marked immediately with a pencil. This is best done under ultraviolet light.

Table 1. Dextrose Solution, 16 hr. in *n*-Propanol (6) : Ethyl Acetate (1) : Water (3)

Amount applied (mgm.)	Amount recovered	Difference
9·95	10·04	0·09
9·88	9·95	0·07

Table 2. Mixture of Lactose and Sucrose, 16 hr. in *n*-Propanol (6) : Ethyl Acetate (1) : Water (3)

Solution applied (ml.)	Sugar	Amount applied (mgm.)	Amount recovered (mgm.)	Difference (mgm.)
0·1955	Sucrose	19·55	19·72	0·17
	Lactose	4·89	4·98	0·09
0·1962	Sucrose	19·62	19·90	0·28
	Lactose	4·91	4·98	0·07

This spray was first proposed by Bradfield and Flood[3] for the detection of polyhydric alcohols (with which it was said to give a strong reaction) in the presence of sugars. Under the conditions described here, it was found to show up sugars satisfactorily. A complex is probably formed between the sugar and the boric acid, giving rise to a stronger acid than boric alone.

The rings containing the sugars are cut out. A short length of filter paper is attached to each ring and this is fastened to dip into a trough filled with water in a normal chromatography cabinet. The sugars are eluted by capillary flow into flasks placed at the bottom of the cabinet. They are then estimated by the complexometric method of Potterat and Eschmann[4,5]. This is particularly suitable for the amounts separated as it gives good results over the range 2–40 mgm. of sugar.

In order to check whether the indicator had any effect on the sugar, pure dextrose solution was chromatographed. The results are given in Table 1.

The completeness of resolution can be seen from results on a solution containing 10 per cent sucrose and 2·5 per cent lactose. This was chosen to simulate the sugars in milk chocolate (Table 2).

Most sugars found in foods can be separated by one overnight run in *n*-propanol (6) : ethyl acetate (1) : water (3). In order to separate dextrose and fructose, four successive runs in formic acid (1) : *n*-butanol (5) : water (4) were found necessary. The first run is carried out overnight. The paper is then dried, run again and, for this and the next runs, is dried as soon as the solvent reaches the edge. Maltose and lactose could not be separated.

Thanks are due to Mr. G. H. Beere for his help and to Dr. A. A. Houghton, who directed this work.

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Incorporation of Phosphorus-32 into the Malpighian Tubes during the Metamorphosis of *Culex pipiens*

The Malpighian tubes are organs with a secretory and a regulatory function with regard to water and salt balance. Studies were made to determine whether, and how, they influence the phosphate-level of larvæ and pupæ of *Culex pipiens* during metamorphosis.

The application of phosphorus-32 was accomplished very simply by placing larvæ in tap water containing different concentrations of radioactive phosphorus. Pupæ did not take up phosphorus from the environment. In order to determine whether the incorporation of phosphorus-32 into the Malpighian tubes varies during metamorphosis, the following experiment was carried out. Early and late 4th instar larvæ were put into a solution of phosphorus-32 for 24 hr. and then removed to tap water. Twenty-four hours after the administration of the phosphorus, the Malpighian tubes were isolated from the larvæ and from pupæ which had reached the pupal stage during the time of application of phosphorus-32. The radioactivity was measured by means of a Geiger-Müller counter. The age of the animals used was determined by the size of the leg and wing *Anlagen*.

The changes in the incorporation of phosphorus-32 into the Malpighian tubes of larvæ and pupæ are shown in Fig. 1. A great accumulation of phosphorus-32 occurs in the cells of the Malpighian tubes of 4th instar larvæ near pupation and in the pupæ. The amount then remains more or less constant during the rest of metamorphosis. The greatest part of the phosphorus-32 is incorporated in acid-soluble substances (10 per cent trichloracetic acid or 2 per cent perchloric acid) (Fig. 1). The small amount of residual phosphorus-32 occurs as ribonucleic acid, lipoids and phosphoproteins, as can be concluded from digestion with ribonuclease and from extraction experiments.

The phosphorus is localized in granules about 1–3μ in diameter. These granules are absent from the Malpighian tubes of young 4th instar larvæ. They make their appearance for the first time in larvæ nearing pupation, and then persist into the imagos (Fig. 2). They show a strong affinity for basic dyes and are soluble in 5 per cent trichloracetic acid or 2 per cent perchloric acid. Toluidine-blue is bound in the metachromatic form which is, furthermore, not resistant to an alcohol treatment. The real nature of the phosphates is not yet clear. Possibly they are polyphosphates, which occur in many lower organisms[1] and which could also be demonstrated in some insects[2]. These phosphate-containing granules are

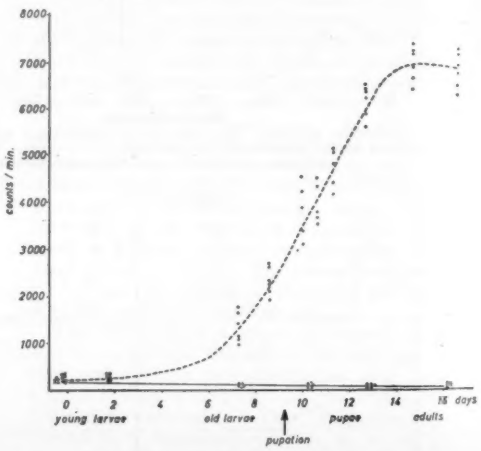

Fig. 1. The incorporation of phosphorus-32 into the Malpighian tubes of *Culex pipiens* during metamorphosis. – – – –, phosphorus-32 accumulated in the cells; ———, after extraction with 10 per cent cold trichloracetic acid

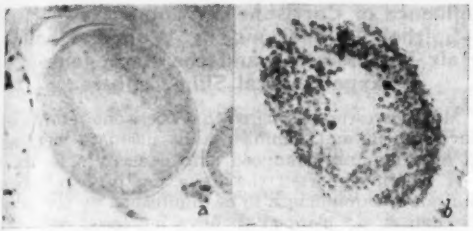

Fig. 2. Section through the Malpighian tubes of *Culex pipiens* treated with phosphorus-32. (*a*) 4th instar larvæ; (*b*) three-day old pupæ. Toluidine-blue stain

comparable with the granules in the Malpighian tubes of blowflies, which were analysed in detail by Waterhouse[3].

The phosphorus-32 reaches the Malpighian tubes by way of the blood. This can be concluded from experiments on animals in which the gut has ceased to show radioactivity. In spite of this absence of radioactivity in the gut, accumulation of phosphorus-32 occurs in the Malpighian cells; hence the phosphorus-32 could not have originated from the gut content, but must have been taken up from the blood.

Table 1. Amounts of Phosphorus-32 (as a Percentage) which can be extracted from Entire Animals (*Culex pipiens*) by Various Solvents

The animals lived in a solution containing phosphorus-32 for 24 hr. and in normal tap water for 24 hr. before the extractions were made

	Alcohol-ether	Perchloric acid (2%)	Perchloric acid (10%)	Residue
Early 4th instar larvæ	35·4	22·4	28·8	13·4
Late 4th instar larvæ	29·4	41·1	24·1	5·4
Young pupæ	25·3	46·1	22·2	6·4
Old pupæ	24·7	45·3	21·6	8·4

The amount of acid-soluble phosphorus-32 in the animals increases during metamorphosis (Table 1). This is in accordance with the quantitative determination of phosphate[4]. We have shown (unpublished experiments) that it originates from the histolysed organs (especially the gut) in which the synthesis of phosphorus-containing compounds rapidly declined and the breakdown of these substances was accelerated. It seems that this increased level of inorganic phosphates in the blood is partially compensated for by the Malpighian tubes, which take up and store the phosphate. The conclusion is justified that the Malpighian tubes are active in the regulation of phosphate balance in the animal, and take part in the processes of histolysis and histogenesis.

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Synthesis of (L) α-2,4-Dinitrophenylhistidine

The reaction of histidine with 1 : 2 : 4-fluorodinitrobenzene (FDNB) could yield a di-substituted histidine and two mono-substituted histidines. Didinitrophenylhistidine has been prepared in pure form[1-4], and although the isolation of a monodinitrophenylhistidine has been claimed[1], neither physical constants nor proof of structure were given. Later workers have not been able to prepare either of the mono-substituted compounds in pure form[4,5]. Efforts to synthesize α-dinitrophenylhistidine were recently reported to have resulted in mixtures containing equal amounts of imidazole dinitrophenylhistidine and α-dinitrophenylhistidine[5].

The present synthesis of α-dinitrophenylhistidine was conceived as a result of chromatographic analysis (Fig. 1) of the products formed in the reaction between histidine and 1 : 2 : 4-fluorodinitrobenzene when the ratio of reagent to amino-acid was varied within wide limits. Examination of the chromatogram suggested that, with 0·5 mole of the fluorodinitrobenzene and 1·0 mole of histidine, only a mono-substituted compound was formed. With larger amounts of reagent this was transformed to the di-substituted compound; the transformation was complete when more than two moles of the reagent were present. The spot obtained with the lower concentration of fluorodinitrobenzene was ninhydrin-negative and reacted strongly positive to the Pauly diazo test. This indicated that the product was α-dinitrophenylhistidine, and suggested reaction conditions for its preparation.

Pure α-dinitrophenylhistidine was prepared as follows: 1·917 gm. (0·01 mole) of L-histidine monohydrochloride and 8·4 gm. of sodium bicarbonate were dissolved in 200 ml. of water, and 0·453 gm. (0·0025 mole) of 1 : 2 : 4-fluorodinitrobenzene in 25 ml. of ethanol was added with stirring. After 1 hr. at room temperature, the volume was reduced *in vacuo* to 50 ml., the *p*H adjusted to 6·5 by

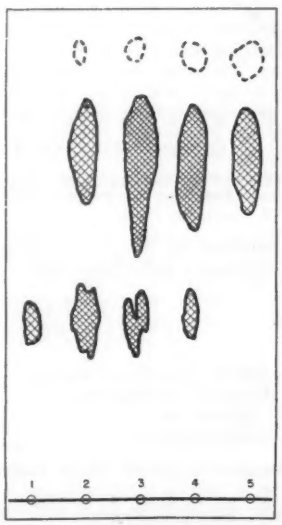

Fig. 1. Chromatogram of the yellow products resulting from the dinitrophenylation of 1 mole histidine for 3 hr. at room temperature with the following amounts of 1 : 2 : 4-fluorodinitrobenzene: (1) 0·5 mole; (2) 1·0 mole; (3) 1·5 mole; (4) 2·0 mole; (5) 2·5 mole

cautious addition of concentrated hydrochloric acid and the solution chilled to 5–10° C. The precipitate was removed by filtration and recrystallized from a minimum volume of dilute alcohol in water. The shiny yellow crystals obtained after 18 hr. in the cold were collected and dried *in vacuo* at 60° C.

Yield: 0·15 gm.
Melting point (uncorr.): 278–280° C. (decomp.).
Specific rotation: $[\alpha]_D^{25}$ − 100·9° (0·154 per cent, 4 *N* hydrochloric acid).
Analysis: found, C, 44·94; H, 3·405; N, 21·59 per cent; calculated for $C_{15}H_{11}O_8N_5$, C, 44·86; H, 3·45; N, 21·79 per cent.

The compound is ninhydrin-negative, indicating substitution of the α-amino group. The Pauly test[6] for the unsubstituted imidazole ring is strongly positive and, mole for mole, is of approximately the same intensity as given by histidine (Fig. 2). The absorption maximum for α-dinitrophenylhistidine in 92 per cent acetic acid is at 342·0 mμ, while that for the disubstituted compound is at 352·0 mμ. The material gives a single spot on paper chromatograms, with R_F = 0·32 (in water-saturated butanol) and 0·43 (in butanol/formic acid/water; 75 : 15 : 10).

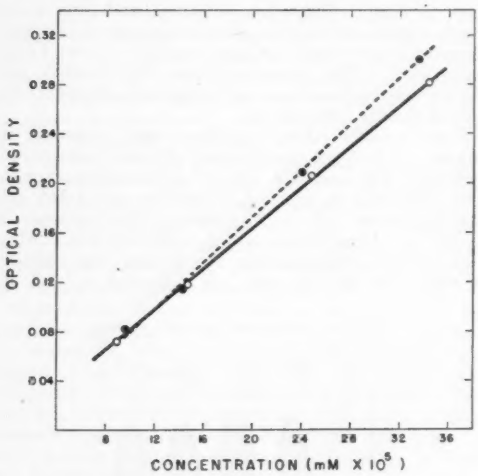

Fig. 2. Intensity of Pauly test for histidine and α-dinitrophenylhistidine. O—O, Histidine; ●—●—, α-dinitrophenylhistidine

We are indebted to Mr. J. A. Baignee for the carbon and hydrogen determinations.

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Influence of Cortisone on Connective Tissue—Epithelial Relations in Wound Healing, Hair Regeneration and the Pathogenesis of Experimental Skin Cancers

Most investigators agree that cortisone retards the development and diminishes the ultimate incidence of experimentally induced skin cancers[1]. Boutwell and Rusch[2] reported the induction of papillomata but not of carcinomata to be diminished by cortisone. Piccagli *et al.*[3] claimed to have increased induction of tumours with methylcholanthrene by cortisone. These differences in opinion may perhaps be attributable to variations in dosage, route and time of administration of cortisone relative to the application of carcinogens. This seems likely, since Baker[4], and we too, have shown that cortisone suppresses hair growth, while Andreasen and Engelbreth-Holm[5] demonstrated that tumour incidence depends on the phase of the hair-cycle at the time of application of the carcinogen.

We have studied the effects of cortisone on the histogenesis of wound healing in rabbits and on hair regeneration after plucking, and the pathogenesis of tumours in mice treated with methylcholanthrene, special attention being devoted to epithelial – connective tissue relations. We have found, *inter alia*, that cortisone affects wound healing in rabbits primarily by depressing the activity of the connective tissue. Whereas, both in rabbits and in mice, cortisone produces marked thinning of both dermis and epidermis, wounding in rabbits and plucking of hair and painting with methylcholanthrene in mice induce marked localized epithelial hyperplasia and regeneration even though connective tissue responses are still suppressed. However, epithelial 'invasions' of the new connective tissue (ultimately formed despite the action of cortisone) and 'pseudo-peg' formation, described by us as a constant reaction in healing wounds[6], are suppressed by cortisone.

Local application of cortisone in mice, to an area previously depilated by plucking, completely inhibits hair regeneration in the treated area. This seems to be due to suppression of invasion of dermis by new epidermal *Anlagen* as well as to the apparent inability of cortisone-suppressed connective tissue to form new hair papillæ, despite the presence of normal epidermal hyperplasia in the plucked areas.

Cortisone injections fail to suppress epithelial thickening and keratinization localized to the area painted with methylcholanthrene in mice. However, dermal atrophy and loss of subcutaneous fat are marked in mice receiving cortisone injections, and invasion of dermis by healing epidermal spurs is distinctly suppressed. Macroscopically, hair regeneration and the incidence of papillomata and carcinomas are significantly depressed, although on microscopic examination we found that malignant change occurs within the epidermis of cortisone-treated mice. Consequently, numerous carcinomata *in situ*, comparable with Bowen's disease in man, were encountered microscopically in cortisone-treated mice, even when neoplasms were not detectable macroscopically. This accounts for the discrepancy between the macro- and microscopically determined incidence of tumours, and for the apparent delay, but not suppression, of carcinogenesis by cortisone.

Thus, in two separate and slightly differently designed experiments, papillomas occurred in seven-

teen of eighteen control methylcholanthrene-painted mice, and in only seven of the seventeen in the methylcholanthrene plus cortisone group; the numbers of papillomas averaged 6·5 per mouse in the former, compared with 1·6 per mouse in the latter. Furthermore, macroscopically detectable carcinomas occurred in fifteen of eighteen controls, and in only seven of seventeen cortisone-treated mice. In one experiment, all ten controls examined microscopically showed malignant tumours (as compared with nine out of ten macroscopically), while in the cortisone group, only three mice showed macroscopically observable malignancies, and eight of nine animals had microscopically detectable carcinomata *in situ* which were quite unrelated to papillomas.

Thus, cortisone does not eliminate the epidermal response evoked by wounding, hair plucking or by treatment with methylcholanthrene. However, the suppression by cortisone of the usual connective-tissue responses to these stimuli influences the histogenesis of wound healing, hair regeneration and tumour development. Although the incidence of papillomas, and the subsequent neoplasia in such benign tumours, is diminished by cortisone, neoplasia within the epidermis itself is not eliminated. Thus, the pathogenesis and biology of these malignant tumours are distinctly altered.

Our histochemical findings, combined with information from the literature, indicate that cortisone seems to induce its effects by acting on the ribose nucleic acid and/or mucopolysaccharide metabolism of the dermis, thereby indirectly influencing epidermal responses to various stimuli.

These findings show, in yet another way, the probable role of the dermis and of disturbed dermal–epidermal relations in the pathogenesis of skin tumours, and suggest a new approach to the investigation of the influence of steroid hormones on carcinogenesis.

The expenses incurred during this study were defrayed primarily by a generous grant from the Schlesinger Organization, South Africa. We wish to thank Mr. W. A. Michie of Ciba, Ltd., Mr. F. Wayne of British Drug Houses, Ltd., and especially Mr. A. M. Patt of Scherag, Ltd., for cortisone used in this study.

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Influence of Osmotic Pressure on the Polyamine Requirement of *Neisseria perflava* and *Pasteurella tularensis* for Growth in Defined Media

THE discovery by Herbst and Snell[1] that putrescine or related di- and poly-amines constitute an essential growth requirement for *Haemophilus parainfluenzae* assigned for the first time a biological function to these substances, known to be of wide occurrence in Nature[2]. Afterwards, putrescine was recognized as an indispensable growth factor for *Neisseria perflava*[3] and a stimulatory agent for *Pasteurella tularensis*[4]. The aim of the present communication is to describe an interrelationship observed between the tonicity of the medium and the polyamine requirement. This observation seems to throw light on the mechanism of the growth-promoting action of these compounds.

Nemes, Pelczar and Doetsch[5] reported that *N. perflava* can be cultivated in a semi-synthetic medium composed of a vitamin-free acid-hydrolysate of casein, salts and biotin. Later, Martin, Pelczar and Hansen[3] found an additional demand of the organism for either putrescine or some other related polyamine, on replacing casein hydrolysate in the above medium by a mixture of eighteen amino-acids.

These results have been fully confirmed by us with two strains of *N. perflava*. The ability of the microorganism to dispense with putrescine in a medium prepared from a commercial acid-hydrolysate of casein ('Casamino-acids', Difco) suggested the possibility that the hydrolysate might contain, as a natural contaminant, sufficient amounts of an active polyamine not removable by the treatment employed for the preparation of the vitamin-free product. However, this was scarcely compatible with the finding that a tryptic digest of casein did not sustain growth unless supplemented with microgram quantities of either putrescine or spermine. A similar result was obtained with a 'salt-free' casein hydrolysate prepared by digestion with sulphuric acid followed by neutralization with barium hydroxide.

As the commercial hydrolysate was known to contain about 40 per cent sodium chloride, a possible effect of the latter substance was suspected. In fact, an ashed sample of 'Casamino-acids' was found to retain all the activity of the original preparation. Moreover, addition of graded amounts of sodium chloride to the defined medium of Martin *et al.*[3] or to an enzymatic casein digest produced, up to a certain concentration, nearly proportional growth responses. The maximal response was, however, somewhat inferior to that obtained with optimal amounts of putrescine. Sodium chloride could be successfully replaced not only by other salts of the alkaline series (potassium, lithium) but also by certain non-electrolytes (glucose, sucrose) (see Table 1). The optimal range of activity corresponded roughly to salt concentrations isotonic with $0{\cdot}1\ M - 0{\cdot}15\ M$ sodium chloride. With non-electrolytes the onset of growth was usually delayed, but the final yield was nearly as good as with sodium chloride. Maximal growth with glucose or sucrose was achieved at concentrations close to $0{\cdot}1\ M$.

In the light of the above results, it appeared interesting to see whether a similar interdependence between the tonicity of the medium and the polyamine requirement can be demonstrated with strains of *P. tularensis* which, as previously shown, require both sodium and spermine for optimal growth[6]. With strain 176, it was found that sodium chloride and

Table 1. Comparison of the Growth-promoting Effect of Spermine and Various Osmotically Active Substances

N. perflava was grown in the defined basal medium of Martin *et al.* (ref. 3) supplemented with 0·2 per cent glucose. *P. tularensis* was grown in the synthetic medium *B* as described in ref. 6. The inoculated tubes were slanted and incubated with continuous shaking at 30°. Growth was estimated in the Coleman Junior spectrophotometer and recorded in terms of optical density. × 100

Additions to basal media	Growth	
	N. perflava (48 hr.)	*P. tularensis* (36 hr.)
None	2	9
Spermine, 10 μgm./ml.	68	36
Sodium chloride, 0·1 *M*	40	30
Sodium chloride, 0·15 *M* + spermine, 10 μgm./ml.	68	70
Potassium chloride, 0·19 *M*	50	32
Glucose, 0·1 *M*	31	25
Sucrose, 0·1 *M*	38	28
Mannitol, 0·1 *M*	2	27

spermine could be substituted for each other to a large extent, though maximal rate of proliferation was obtained only when both factors acted in combination (Table 1). Here, too, the growth-enhancing effect of sodium chloride could be duplicated by other salts as well as by non-electrolytes.

In the course of this work, it was observed that washing *P. tularensis* cells with distilled water instead of the usual saline resulted in a decrease of their viability as shown by prolongation of the lag phase or even by complete suppression of multiplication. This deterioration could be prevented by adding some micrograms of spermine to the distilled water used for washing. Thus, in this respect again, sodium chloride and spermine proved to be interchangeable.

The results presented so far seem to justify the general conclusion that both the osmotic agents and the polyamines control, each independently and by a different mechanism, some definite cell function essential for growth. It appears likely that this vital function may be related to permeability of the cell membrane; no conclusion as to the exact mechanism involved is yet possible.

J. Mager

Department of Biochemistry,
The Hebrew University-
Hadassah Medical School,
Jerusalem. June 28.

[1] Herbst, E. J., and Snell, E. E., *J. Biol. Chem.*, **181**, 47 (1949).
[2] Guggenheim, M., "Die biogenen Amine" (3rd edit., Basel, 1940).
[3] Martin, J. H., Pelczar, jun., M. J., and Hansen, P. A., *Science*, **116**, 483 (1952).
[4] Mager, J., Traub, A., and Grossowicz, N., *Nature*, **174**, 747 (1954).
[5] Nemes, J. L., Pelczar, jun., M. J., and Doetsch, R. N., *J. Infect. Diseases*, **88**, 156 (1951).
[6] Traub, A., Mager, J., and Grossowicz, N. J., *Bacteriol.* [**70**, 60 (1955)].

Systematic Position of the Euphausiacea

Elsewhere in this issue of *Nature* (see p. 911) I have mentioned that, although the idea originated with Kemp, Gurney was the first to place the Euphausiacea in the order Decapoda, which he divided into two suborders, Euphausiacea and Eudecapoda. Gurney never intended to include the Euphausiacea in his Ray Society monograph, "Larvæ of Decapod Crustacea" (1942)—Euphausid literature is omitted from the earlier companion volume, "Bibliography of the Larvæ of Decapod Crustacea" (1939)—but a chance remark of mine prompted him to do so when his manuscript was almost, or quite, finished. This resulted in some inconsistency of treatment of the Euphausiacea, partly because he sometimes omitted to alter 'Decapoda' to 'Eudecapoda' where necessary, partly because he had already mentioned the Euphausiacea (as an independent order) here and there, in the same way as he mentions the Stomatopoda, for example. He did not explain why he altered the classification; Kemp's idea was quite new to him and he doubtless misunderstood what I said. That he had not considered the matter carefully is proved by the letter which he sent me in 1949 after we had again discussed the systematic position of the Euphausiacea (see p. 911 for his suggested solution, which has much in its favour). Incidentally, Nakazawa's claim, referred to by Gurney[1], that an economically important Japanese species of *Sergestes* has a free nauplius larva is sound. Recently I had the relevant passage translated; Nakazawa collected sixty eggs on August 6, from the fishing grounds, and from these he obtained the three naupliar stages which he figured; eighteen of the third-stage nauplii metamorphosed to the first-stage protozoea, which is an undoubted Sergestid larva.

All carcinologists would, I think, agree that the general classification of the Decapoda is in urgent need of revision. According to Gurney (ref. 1, p. 11), "the four main difficulties in framing a satisfactory system for the Decapoda are: (i) relation of the Euphausiacea to the Decapoda; (ii) relation of the Penaeidea to the Caridea; (iii) position of the Stenopidea and of the Thalassinidea; (iv) relation of the Dromiacea to the Brachyura"; and there are others. On embryological grounds, Gurney altered the position not only of Euphausiacea but also of Stenopidea, Thalassinidea and Dromiacea. Moreover, he maintains that the Thalassinidea is not homogeneous but comprises a homarine and an anomuran group. It would be interesting to follow this up with reference to adult morphology, to see whether or not Gurney's views can be substantiated. In a forthcoming paper I hope to discuss more fully the systematic position of the Euphausiacea; as I also intend to consider the relationships of the Dromiacea and of the Gymnopleura, and perhaps of other groups as well, it may be some time before the work is finished. Meantime I would welcome any suggestions or comments that may occur to other specialists.

Isabella Gordon

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Cromwell Road, London, S.W.7.

[1] *Discovery* Reports, **20**, 4 (1940); Ray Society Monograph, 1942, 39, footnote.

Chainia, a New Genus of the Actinomycetales

An actinomycete isolated from soil in Poona showed on examination characters representing an undescribed genus. The species was saprophytic, aerobic and mesophilic, growing readily on the various nutrient agar media employed. The colonies on glucose–peptone agar are faint cream-yellow in early stages, with well-developed fine non-septate mycelium, 0·4–0·8μ in diameter and branching in a monopodial type. The hyphæ developing in a radiating manner grow into the substrate, giving a lichenoid appearance. There is no true aerial mycelium formed, though growth at later period appears compact and raised. The unseptate mycelium never fragments into bacillary or coccoid forms and is Gram-positive and non-acid fast.

The chief distinguishing character of the genus is the formation of spherical sclerotic granules in large

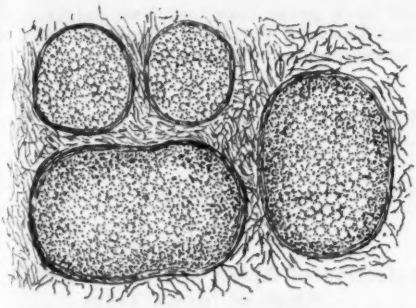

Fig. 1. Sclerotic granules in *C. antibiotica*. × 500

aggregate masses from the mycelium (Fig. 1). In their formation, closely septate hyphæ thickened up to 1·5μ, incurl and become compacted to form hard sclerotic granules ranging from 16 to 75μ in diameter. There is an enveloping layer of mycelium, or in some cases several small granules become enclosed in a common mycelial sheath. In old colonies, the granules become readily separated from the vegetative mycelium and on transferring to fresh media germinate and develop into new colonies.

Comparative studies indicated that the occurrence of a branching non-septate mycelium without true aerial mycelial formation shows affinity with *Micromonospora* Orskov, but lacks the characteristic single spores produced in the latter genus. The type of sclerotic granules resemble in a general way those present in *Actinomyces bovis* Harz. and *A. isreaeli* (Kruse) Lachner-Sandoval, which incite actinomycoses in higher animals[2]. The granules in the *Actinomyces* species mentioned above are structurally different, with radiating 'clubs'. Further, the genus *Actinomyces* Harz (*sensu* Waksman and Henrici[1]) has a vegetative mycelium fragmenting into bacillary or coccoid forms, and is mainly anaerobic to microaerophilic. In contrast, the species under study has a true mycelium as in Streptomycetaceae and is aerobic and mesophilic. These characters indicate that the species under study represents an undescribed genus, for which the name *Chainia* is proposed, in honour of Prof. E. B. Chain, of the Istituto Superiore Sanità, Rome.

Chainia Thirumalachar *gen. nov.*: mycelium well developed, fine, non-septate, growing into substrate, not forming true aerial mycelium, non-fragmenting, Gram-positive, non-acid fast, developing sclerotic granules composed of incurled hyphal cells, single or in aggregates, enveloped in hyphal sheath at first and later becoming free. Conidial form unknown. Type species: *Chainia antibiotica* Thirum., isolated from soil, Poona, India.

Studies on antibiotic activity have indicated that *C. antibiotica* produces a very powerful antifungal substance both on agar plates and in agitated submerged cultures in shake flasks. While the nature of the substance is under test, the general antibiotic spectra indicated on agar streak tests is given in Table 1. A fragment of mycelium of *C. antibiotica* 2 mm. in diameter was inoculated on glucose peptone agar for five days in Petri dishes (10 cm. diam. with 20 c.c. of medium), incubated at 24° C. and tested for antifungal or antibacterial activity.

Table 1

Name of organism tested	Diam. of zone of inhibition
Cryptococcus neoformans	70 mm.
Sporotrichum schenkii	50 mm.
Microsporum audouini	50 mm.
Saccharomyces sp.	60 mm.
Curvularia lunata	60 mm.
Penicillium chrysogenum	50 mm.
Botryodiplodia phaseoli	45 mm.
Bacillus subtilis	40 mm.
Micrococcus pyogenes var. *aureus*	45 mm.
Escherichia coli	Nil

Detailed accounts of the description of the species and genus, biochemical and antibiotic activities will be published separately.

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[1] Waksman, S. A., and Henrici, A. T., *J. Bact.*, **46**, 337 (1943).
[2] Waksman, S. A., "The Actinomycetes", *Ann. Crypt. et Phytopath.*, **9**, 230 (Chronica Botanica, 1950).

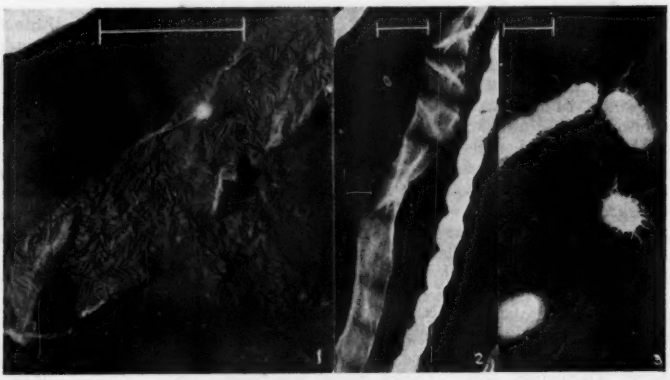
Spore Formation in the Genus *Streptomyces*

In the course of a study of the Streptomycetes present in New Zealand soils, the electron microscope revealed certain details of spore formation which may be of interest.

Micrographs of a number of named cultures as well as of freshly isolated material give support to the views expressed so far back as 1898 by Lachner-Sandoval[1].

Spore formation takes place within the hyphal wall. The contents divide into fragments which are separated by less dense partitions, having the appearance of septa. The fragments are somewhat irregular in size and divisions appear to occur simultaneously along the hypha.

The spores remain in chains, held together by the sheath-like hyphal wall. As the spores mature, the nature of the sheath appears to undergo change. In some strains it persists, the spores being liberated by means of a longitudinal split, and the old wall is seen as a ribbon-like sheath. The sheath may have cross markings that show clearly the positions of the spores it formerly enveloped (Fig. 2). In other strains



Scale length 1 μ

the sheath disintegrates readily and small fragments only remain to indicate its presence.

Micrographs of the sheath show a definite structure. Narrow pointed plates lie side by side in groups at various angles, the whole presenting a more or less regular pattern as if crystalline (Fig. 1). The persistence of the sheath seems to be associated with the degree of marking. The most strongly patterned sheaths observed were those which broke up readily, apparently fragmenting parallel to the long axes of the narrow plates.

Using the technique of Erikson[2], the sheath did not stain with sudan IV.

Attached to the sheath and sometimes enfolded by it, small dense spherical bodies were frequently observed. These inclusions varied in size from 0·1μ to 0·2μ. The nature and function of these bodies are not known (Fig. 1). Electron micrographs of *Nocardia ruber*[3] show granules which may be similar.

The presence of spiny processes on the spores of certain strains was reported by Flaig *et al.*[4], and several isolates from New Zealand soils have been noted to produce spores with spiny outgrowths. Micrographs show that spores with spines are produced within the hyphal wall in the normal manner, and are liberated by a longitudinal splitting of the sheath. The sheath shows clearly markings and indentations caused by the spines. In some cases the spines were observed to penetrate the hyphal wall and occasionally were broken off when the spores were released.

As no previous record has been seen, it is of interest to note that a culture of *S. flaveolus* NRRL. B.1334 showed spiny spores. The spines on the spores of *S. flaveolus* are long and thin (1μ × 0·04μ) tapering only slightly towards the tip. They are very fragile and easily broken off (Fig. 3).

I am indebted to Mr. K. I. Williamson and Mr. W. Bertaud of the Dominion Physical Laboratory for the electron micrographs.

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July 6.

[1] Lachner-Sandoval, V., "Ueber Strahlenpilze" (Strassburg, 1898). Quoted by Waksman, S. A., "The Actinomycetes" (1950).
[2] Erikson, D., *J. Gen. Micro.*, **1**, 39 (1947).
[3] Jones, K. L., *Ann. N.Y. Acad. Sci.*, **60**, 124 (1954).
[4] Flaig *et al.*, *Plant and Soil*, **4**, 118 (1952).

Isolation of *Microsporum gypseum* and of *Keratinomyces ajelloi* from Australian Soil

Sixty-six samples of soil collected from various parts of New South Wales were examined for the presence of keratinophilic fungi. Following the technique of Vanbreuseghem[1], Petri dishes half-filled with moistened soil were baited with autoclaved human hair. At varying intervals, ranging from three to seven weeks, some hairs were found to be overgrown by fungi; these were examined microscopically and transferred to Sabouraud's agar containing 'Actidione' (*cyclo*heximide), penicillin and streptomycin[1].

Microsporum gypseum was isolated in pure culture from five samples of soil and *Keratinomyces ajelloi* from eight samples. So far as we know, this is the first occasion on which these fungi have been isolated from Australian soil. Other fungi are being encountered in the course of this work, which is supported by a grant from the National Health and Medical Research Council of Australia and which will be reported in full later.

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D. Frey

Institute of Medical Research,
Royal North Shore Hospital,
Sydney, New South Wales. June 14.

[1] Vanbreuseghem, R., *Ann. Soc. Belge Méd. Trop.*, **32**, 173 (1952).
[2] Ajello, L., *J. Invest. Dermat.*, **21**, 157 (1953).

Selection of Aphid Species by Different Kinds of Insect Traps

Moereke yellow trays are a simple and cheap method of trapping aphids, and are being widely used for the study of aphid flight and behaviour. These traps, however, have never been standardized with respect to their differential catch of various species. Three yellow trays and a suction trap were operated close to each other, over a small plot of pyrethrum not infested with aphids, for more than two years at the East African Agriculture and Forestry Research Organization, near Kikuyu, Kenya. There are reasons for thinking that the suction trap takes a fairly accurate sample of aphid density. The ratio of yellow-tray to suction-trap catch for the commoner species is shown in Table 1. The total number of specimens, from both traps, is placed in parentheses. All the specimens listed were alate viviparous females except for the male *Rhopalosiphum maidis*.

Table 1. Ratio of Catches in Yellow Trays to those by Suction Trap

1	*Toxoptera citricidus*	30·7	(95)
2	*Myzus ornatus*	25·0	(52)
3	*Macrosiphum euphorbiae*	14·7	(771)
4	*Hyadaphis coriandri*	12·7	(41)
5	*Brevicoryne brassicae*	11·1	(799)
6	*Brachycaudus helichrysi*	9·5	(21)
7	*Trifidaphis phaseoli*	9·5	(21)
8	*Myzus persicae*	6·4	(844)
9	*Aphis* spp.	3·3	(2,048)
10	*Hyperomyzus lactucae*	2·9	(27)
11	*Lipaphis erysimi*	2·7	(720)
12	*Longiunguis sacchari*	2·7	(76)
13	*Dactynotus compositae*	2·2	(305)
14	*Aulacorthum vincae*	2·1	(49)
15	*Geoica lucifuga*	2·1	(25)
16	*Rhopalosiphum maidis* ♂♂	2·0	(51)
17	*Tetraneura hirsuta*	1·6	(102)
18	*Aploneura lentisci*	1·5	(168)
19	*Rhopalosiphum splendens*	1·3	(734)
20	*Micromyzus ageni*	1·2	(35)
21	*Macrosiphum* (*Sitobion*) spp.	0·8	(261)
22	*Rhopalosiphum maidis* ♀♀	0·8	(972)
23	*Schizaphis cyperi*	0·6	(344)
24	*Acyrthosiphon pisum*	0·5	(414)

From these figures it is evident that some species may be selected as much as thirty times as strongly as others by yellow trays than by suction traps. The host plants of species 1–11, 13 and 14 and 24 are dicotyledons, and of 12 and 15–23 are grasses or sedges. These grass- and sedge-feeding species belong to several different taxonomic groups, and the yellow trays select against them in favour of most of the common species feeding on dicotyledons.

Statistical analysis of these trap catches from hour to hour shows that the presence of sunshine increases the yellow-tray catch relative to the suction trap: these findings are to be published in greater detail elsewhere.

V. F. Eastop

East African Agriculture and
Forestry Research Organization,
P.O. Box 21,
Kikuyu. July 11.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 14

INSTITUTE OF METAL FINISHING (in the Thames Room, Charing Cross Hotel, London, W.C.2), at 11 a.m.—Annual General Meeting. At 3 p.m.—Mr. R. A. F. Hammond: "Research and Industrial Application in Metal Finishing" (Presidential Address).

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. R. A. Hamilton and others: "Scientific Research by the North Greenland Expedition".

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. H. Ezriel: "The Use of Psychoanalytic Sessions as Experimental Situations".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Is the Engineer Broad Enough in his Outlook?". Opening Speaker: Dr. P. Dunsheath.

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. S. Feldberg, F.R.S.: "Recent Experiments on the Pharmacology of the Periventricular Grey Matter of the Brain".*

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the Woolwich Polytechnic Scientific Society, at the Woolwich Polytechnic, London, S.E.18), at 7.30 p.m.—Dr. T. V. Arden: "Ion Exchange Resins".

Tuesday, November 15

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. F. E. Adams and Mr. A. G. Baker: "An Assessment of Dry-Blending Equipment".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT SECTION (joint meeting with the RADIO SECTION, at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. D. L. Holloway: "An Electrolytic-Tank Equipment for the Determination of Electron Trajectories, Potential and Gradient" and "A Method of Tracing Electron Trajectories in Crossed Electric and Magnetic Fields" (Papers to be read by Dr. J. H. Westcott).

UNIVERSITY OF LONDON, BRITISH POSTGRADUATE MEDICAL FEDERATION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. R. E. Tunbridge: "Observations on the Structure of Connective Tissue Fibres". (Sixth of fifteen Lectures on "The Scientific Basis of Medicine".)*

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Sir Ronald A. Fisher, F.R.S.: "The Planning of Experiments".

Wednesday, November 16

ROYAL MICROSCOPICAL SOCIETY, INDUSTRIAL SECTION (at the British Pharmaceutical Society, 17 Bloomsbury Square, London, W.C.1), at 2 p.m.—Exhibition and Symposium on "Fibre Microscopy".

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. G. Popjak: "Fat Metabolism".*

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. Joanne Malkus: "The Effects of a Large Island Upon the Trade-Wind Stream"; Mr. R. P. Pearce: "The Calculation of a Sea Breeze Circulation in Terms of the Differential Heating Across the Coast-line"; Mr. R. C. Smith: "Theory of Airflow Over a Heated Land Mass".*

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Dr. D. J. Finney: "The Statistician and the Planning of Field Experiments".

EUGENICS SOCIETY (in the Rooms of the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. H. C. Maurice Williams: "Problem Families in Southampton".*

RESEARCH DEFENCE SOCIETY (in the Physiology Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Sir Henry Dale, F.R.S.: "Humanity's Rising Debt to Medical Research" (Twenty-fourth Stephen Paget Memorial Lecture).

ASLIB (at the Royal Society of Arts, 8 John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Dr. E. J. Crane: "The Chemical Abstracts Service and its Plans".

IRON AND STEEL INSTITUTE (at the Seymour Hall, Seymour Place, London, W.1), at 6 p.m.—Sir Robert Shone and Mr. W. F. Cartwright: "The Russian Iron and Steel Industry".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Institute of Metals, Grosvenor Gardens, London, S.W.1), at 6.30 p.m.—Annual General Meeting. Dr. D. W. Kent-Jones: "A Progressive Institute".

POLAROGRAPHIC SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 7.30 p.m.—Prof. J. Heyrovsky (Czechoslovakia): Presidential Address.*

Thursday, November 17

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 10 a.m.—Meeting on "Aircraft Design Philosophy"; Dr. P. B. Walker: "Structural Testing"; Mr. H. Giddings: "Fatigue"; Mr. C. F. Joy: "Flight Loads"; Mr. J. K. Williams: "Safety Factors".

UNIVERSITY COLLEGE LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. Kenneth Garside: "The Arrangement of Books: a New System of Classification in the College Library".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. R. A. Smith: "Physics at the Radar Research Establishment, Malvern".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. F. Kingdon-Ward: "Travels in the Great Forest Belt of North Burma".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Annual General Meeting. Prof. J. H. C. Whitehead: "Duality in Topology" (Presidential Address).

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. R. J. P. Williams: "Metal Complexes as Models for Metallo-Enzymes". (Further Lectures on November 24, December 1 and 8.)*

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (in the Lecture Hall of the Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1), at 6 p.m.—Mr. K. E. Clare and Mr. P. T. Sherwood: "Organic Matter in Soil in Relation to Soil-Cement Stabilization".

OIL AND COLOUR CHEMISTS' ASSOCIATION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. E. M. Evans: "Recent Developments in Polyester Resins".

CHEMICAL SOCIETY (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Prof. D. H. Everett: "Some Developments in the Study of Physical Adsorption" (Tilden Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 7.30 p.m.—Laboratory Meeting.

Friday, November 18

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 10 a.m—Symposium on "The Protection of Cable Sheathing".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. C. F. A. Pantin, F.R.S.: "The Primitive Nervous System".

Friday, November 18—Saturday, November 19

INSTITUTE OF PHYSICS, X-RAY ANALYSIS GROUP (at the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1)—Autumn Conference—"Semi- and Non-Crystalline Materials".

Saturday, November 19

BIOCHEMICAL SOCIETY (at the Middlesex Hospital Medical School, Mortimer Street, London, W.1), at 11 a.m.—Scientific Papers.

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. F. N. Ghadially: "Fish, Reptiles and Amphibians".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

TRAINING OFFICER (with an honours degree in chemistry and physics or corporate member of a senior Engineering Institution, or equivalent qualifications, with some years' experience in industry and knowledge of industrial training methods) AT THE INDUSTRIAL GROUP HEADQUARTERS, United Kingdom Atomic Energy Authority, Risley, to take part in the preparation and administration of training courses, and to assist the Chief Training Officer (Operations)—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, near Warrington, quoting 1160 (November 18).

ASSISTANT EXPERIMENTAL OFFICERS (2) (with at least G.C.E. to advanced level in biology, or equivalent qualification, preferably with a degree in biology), at the Merlewood Research Station, Grange-over-Sands, for laboratory work, including microscopical examination and tine manipulation, on microarthropods or nematodes, and some field work—Establishment Officer, The Nature Conservancy, 19 Belgrave Square, London, S.W.1 (November 19).

HEAD, Grade II (with high academic or professional qualifications and considerable full-time teaching experience, preferably with industrial, research or administrative experience), OF THE DEPARTMENT OF CHEMISTRY AND BIOLOGY—The Principal, Norwood Technical College, Knight's Hill, London, S.E.27 (November 19).

LECTURER IN ELECTRICAL ENGINEERING—The Registrar, Queen Mary College, Mile End Road, London, E.1 (November 19).

LECTURER IN SOCIAL PHILOSOPHY—The Secretary, The Queen's University, Belfast (November 19).

RESEARCH ASSISTANT (with a good honours degree in chemistry) IN THE DEPARTMENT OF CHEMISTRY, to work under direction on a project involving radiochemical techniques—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (November 19).

Senior Lecturer (with qualifications and experience necessary to plan and supervise the teaching of physical chemistry up to honours degree standard) in Physical Chemistry—The Principal, Royal Technical College, Salford 5 (November 19).

Statisticians (with a first- or second-class honours degree, or equivalent, in statistics, mathematics, economics or other appropriate subject, or with examinations of approved statistical society) at the Central African Statistical Office, Ministry of Finance, Federation of Rhodesia and Nyasaland—The Secretary, Rhodesia House, 429 Strand, London, W.C.2 (November 19).

Professor of Mechanical Engineering at the University of Ceylon—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 24).

Scientific Officer (with first- or second-class honours degree in chemistry) at the Northern Outfall Works, Beckton, London, for scientific control and development duties—The Medical Officer of Health (PH/D1), County Hall, London, S.E.1 (November 25).

Lecturer (with an honours degree and research experience) in Physics, at Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 28).

Deputy Conservation Officer (graduate in biological science, agriculture or forestry, with some administrative experience, or equivalent qualifications), with the Nature Conservancy in Wales, for duties including the investigation of wild life conservation problems, contacts with Natural History Societies, landowners, local authorities and government departments; co-operation with research scientists and others on management of Nature Reserves—The Establishment Officer, The Nature Conservancy, 19 Belgrave Square, London, S.W.1 (November 30).

Lecturer (with an honours degree in zoology, and preferably a special knowledge of agricultural entomology, with research and teaching experience of this subject) in Agricultural Entomology—The Secretary, School of Agriculture, Downing Street, Cambridge (November 30).

Lecturer (graduate, with special interest in surveying) in Civil Engineering—The Registrar, King's College, Strand, London, W.C.2 (November 30).

Physiologist in the Department of Physiology and Plant Culture, to work on plant response to environment—The Secretary, John Innes Horticultural Institution, Bayfordbury, Herts (November 30).

Professor of Parasitology and Professor of Bacteriology at the University of Ceylon—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 30).

Demonstrator (honours graduate in chemistry) in Chemistry—The Registrar, College of Technology, Manchester 1 (December 1).

Assistant Experimental Officers or Experimental Officers (preferably with a degree in natural sciences or engineering, with statistics) for the Scientific Adviser's Branch, Air Ministry, London, for duties including control of field studies and analysis of data relating to operation of military aircraft, including technical supply problems, logistics and flying safety—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.393/5A (December 3).

Lecturer in Animal Production, and Lecturers (2) in Crop Production, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1 (December 6).

Senior Lecturer (with a research degree in organic chemistry and experience of teaching this subject) in Organic Chemistry at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (December 9).

Research Fellow (with experience in low energy nuclear physics or photo disintegration problems) in the Department of Nuclear Physics, Research School of Physical Sciences, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (December 30).

Lecturer (with an honours degree and practical experience in public works engineering) in Civil Engineering—The Registrar, The University, Leeds 2 (January 2).

Agricultural Engineer (with a university degree in agriculture or engineering and postgraduate training in agricultural engineering) in British Guiana, to be responsible for the general improvement of local practices relating to agricultural engineering, to test and develop new techniques and mechanical devices for field and factory, and to train persons in the care and maintenance of farm machinery—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.63/30/05.

Chemists and Biochemists (with a good honours degree and preferably some research experience) for research on microbiological methods of analyses and the chemistry of cereal lipids—The Director, Research Association of British Flour-Millers, Cereals Research Station, Old London Road, St. Albans.

Demonstrator (graduate in economics, agriculture or geography) in Agricultural Economics, for research and teaching duties—The Secretary, Institute for Research in Agricultural Economics, Parks Road, Oxford.

Mathematician, Principal or Senior Scientific Officer grade (with a first- or second-class honours degree, or equivalent qualification, in applied mathematics and considerable experience in formulation and solution of advanced mathematical problems), at the Ministry of Supply, Armament Research and Development Establishment, near Sevenoaks, Kent, to lead a mathematical team in advanced basic research in either mechanics of fluids, steady and unsteady compressible flow, or of solids, elasticity, plasticity and fracture—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.391/5A (November 26).

Physical Metallurgist (with a university degree, or equivalent qualification, and preferably with some postgraduate research experience) for the British Iron and Steel Research Association, Sheffield, to work in a research group concerned with measurements of fundamental properties of iron and steel—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting M.G.1.

Scientific Officer (with a good honours degree and an interest in biological problems, preferably with research experience) in the Department of Chemistry, to take part in researches on the chemistry of milk proteins and enzymes—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, Berks, quoting 55/19.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The British University System 1914–1954. By Sir Hector Hetherington. (The P. J. Anderson Memorial Lecture, 1954.) (Aberdeen University Studies No. 33.) Pp. 13. (Edinburgh and London: Oliver and Boyd, Ltd., 1955. Published for the University of Aberdeen.) 1s. [108

Annals of the Cape Observatory. Vol. 18: Cape Photographic Catalogue for 1950.0. Zone −35° to −40°. Prepared under the directions of Dr. J. Jackson and R. H. Stoy. Pp. xii+260. (London: H.M. Stationery Office, 1955.) 30s. net. [108

Report of the Conference on Industry and Technical Education. (Organized by the Regional Advisory Council for the Organization of Further Education in the East Midlands and the F.B.I. North Midland Regional Council, and held at the College of Technology, Loughborough, 21 April 1955.) Pp. iii+41. (London: Federation of British Industries, 1955.) 4s. [158

Report of a Sub-committee on University Entrance Requirements. Pp. 20. (London: Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, 1955.) [228

Science Museum. Classified Lists of Historical Events. Mechanical and Electrical Engineering, including Energy Conversion, Transmission and Storage; Atomic Energy; Pumping; Blowing and Compressing Machinery; Explosives and Ordnance. Compiled by G. F. Westcott. Pp. iv+40. (London: H.M. Stationery Office, 1955.) 2s. net. [228

Peaceful Uses of Atomic Energy. Pp. 16. (London: Association of Scientific Workers, and the Labour Research Department, 1955.) 6d. [228

Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Season 1953–54. Queensland. By R. W. Peters. Pp. 16. 9d. Survey of Reports. By J. B. Hutchinson. Pp. 14. 9d. (London: Empire Cotton Growing Corporation, 1955.) [228

Technical Survey of the Copper Development Association. No. 6, July, 1955. Pp. 36. (Radlett: Copper Development Association, 1955.) [228

Air Ministry: Meteorological Office. British Rainfall 1953: Report on the Distribution of Rain in space and time over Great Britain and Northern Ireland during the year 1953 as recorded by about 5,000 observers. (The Ninety-third Annual Volume of the British Rainfall Organization.) Pp. iv+219. (M.O. 588.) (London: H.M. Stationery Office, 1955.) 25s. net. [228

Other Countries

World Health Organization. Technical Report Series. No. 92: Joint ILO/WHO Committee on the Hygiene of Seafarers. Second Report. Pp. 20. 1 Swiss franc; 1s. 9d.; 0.30 dollars. No. 93: Expert Committee on Midwifery Training. First Report. Pp. 21. 1 Swiss franc; 1s. 9d.; 0.30 dollars. No. 96: Expert Committee on Biological Standardization. Eighth Report. Pp. 19. 1 Swiss franc; 1s. 9d.; 0.30 dollars. No. 98: Legislation Affecting Psychiatric Treatment. Fourth Report of the Expert Committee on Mental Health. Pp. 25. 1 Swiss franc; 1s. 9d.; 0.30 dollars. Monograph Series. No. 27: Chemotherapy of Malaria. By Sir Gordon Covell, Dr. Robert Coatney, Dr. John W. Field and Dr. Jaswant Singh. Pp. 123. 10 Swiss francs; 17s. 6d.; 3.25 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1955.) [228

United States Department of Agriculture. Leaflet No. 386: Mosquitoes: How to Control Them on Your Property. Pp. 8. 5 cents. Leaflet No. 388: Horn Flies on Cattle: How to Control Them. Pp. 6. 5 cents. Circular No. 957: Investigations of the Pink Bollworm and Hemipterous Cotton Insects. By L. W. Noble. Pp. 16. 10 cents. Farmers' Bulletin No. 2084: The European Corn Borer and Its Control. Pp. 20. 15 cents. Home and Garden Bulletin No. 46: Insects and Diseases of Vegetables in the Home Garden. By L. R. Reed and S. P. Doolittle. Pp. 64. 25 cents. Picture Sheet No. 21: Pink Bollworm. Pp. 2. 5 cents. (Washington, D.C.: Government Printing Office, 1955.) [228

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 36, No. 6 (June 1955): Cancer in Adults Before Midlife. Pp. 12. (New York: Metropolitan Life Insurance Company, 1955.) [228

Durban Museum Novitiates. Vol. 4, Part 12 (30th June, 1955): Mordellidae and Scraptiidae in the Collections of the Durban Museum. 29: Contribution to the Knowledge of Mordellidae and Scraptiidae. By Dr. Mario E. Franciscolo. Pp. 161–186. Vol. 4, Part 13 (31st July, 1955): Results of the Durban Museum Ornithological Expedition to Pondoland in August, 1954. By P. A. Clancey. Pp. 187–214. (Durban: Durban Museum and Art Gallery, 1955.) [228

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 113, No. 4: A Study of LeConte's Species of the Chrysomelid Genus *Graphops* with Descriptions of Some New Species. By Doris H. Blake. Pp. 263–301+6 plates. Vol. 113, No. 5: The Permian Reptile Araeoscelis Restudied. By Peter Paul Vaughan. Pp. 303–469+2 plates. Vol. 113, No. 6: A Revision of the Australian Ant Genus *Notoncus* Emery, with Notes on the other Genera of Melophorini. By William L. Brown, Jr. Pp. 271–494. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1955.) [228

University of California Publications in Botany. Vol. 28, No. 1. A Study of Half-Chromatid Fragments in Meiosis of the Hybrid Bromus Triniі × B. Maritimus. By Marta Sherman Walters. Pp. 18+2 plates. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1955.) 35 cents. [228